Chemical Demonstrations: The good, the bad, and the ugly.

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ABSTRACT

Chemical demonstrations are how chemistry has been taught for well over 200 years in universities and lecture halls in Europe and the United States. While there are many responsible individuals using chemical demonstrations as part of their teaching and in public programs, there are others who are not trained in proper techniques and safety practices. Students and spectators have been injured as a result poor preparation and practices by their presenters. Then, there are those individuals who strive for the WOW! effect by performing dangerous demonstrations, scaling them up for maximum impact, putting themselves and others at the risk of injury. Demonstrations can be safely performed by proper planning, knowing what they are working with, pretesting, sizing the demonstration appropriately, and taking the proper precautions so that no one is at a risk of injury and nothing is damaged. Safety guidelines by professional organizations are helpful, but do not tell how to do proper demonstrations. This article reviews some selected accidents, recommends alternative materials and procedures, and tells some guidelines for safe and successful demonstrations and hands-on activities.

KEYWORDS

General Public, Elementary/Middle School, High School, College, Demonstrations, Hands-On Learning, Safety, Rainbow Flame Demonstration.

Chemical Demonstrations are a part of the history of chemistry. These were often ticketed events held at scientific institutions, such as The Royal Society in London, or at universities. (see Figure 1.)

Some demonstrations were safer than others, however, audiences loved fire, smoke and explosions that were part of the "show". Unfortunately, when a chemist or chemical educator brings demonstration materials into a classroom or lecture hall, the immediate reaction of the audience is "What are we going to blow up today?"

This author has used in-class demonstrations and hands-on activities along with several hundred workshops in schools, including pre-school through college, and for the public, in hotels, shopping malls, restaurants, community centers, throughout his entire teaching career. He has worked with, and shared demonstrations and activities with, a large number of responsible educators and demonstrators. To the best of his knowledge, there have been no major accidents or injuries from demonstrations and activities from these responsible colleagues.

Figure 1. James Gillray (1757-1815) "Scientific Researches!—New Discoveries in PNEUMATICKS!—or—an Experimental Lecture on the Powers of Air," published May 23, 1802 by H. Humphrey, St. James's Street. (From the collection of David A. Katz. Photo by David A. Katz)

While most demonstrations are effectively used to teach, occasionally, a demonstrator cheats a little in a demonstration to emphasize a point. The late Hubert Alyea was famous for his “pop” bottles filled with a mixture of hydrogen and oxygen and about 5 mL of water. There was always liquid water to pour out of the bottle to illustrate the product of the reaction. In another demonstration, Hubert would burn a candle under a beaker inverted in a dish of water. The water always rose up to occupy approximately 20% of the volume as the candle burned out from lack of oxygen. Hubert had prefilled the dish with a measured volume of water so it always rose up that 20%. Hubert had a major impact on people around the world resulting in many who he influenced to pursue science careers.

The Bad

These are a few of the accidents that have occurred in past years.

On Sept. 3, 2014, a demonstrator at a museum in Reno, Nev., was attempting to create a colored “fire tornado” when she poured methanol from a 4-L container onto a smoldering cotton ball. 13 spectators, mostly children were injured.[2]

On Sept. 15, 2014, a teacher at a high school in Denver was demonstrating flammable properties when he poured methanol from a 4-L container onto an open flame resulting in burns to four students and seriously injuring a fifth student.[3] That teacher was eventually fired.[4]

On Oct. 20, 2014, a Cub Scout group trying to produce a green flame poured methanol-containing antifreeze from a 355-mL bottle onto a fire in Raymond, Ill.[5] Three Cub Scouts and a parent suffered burns to their faces, hands, and arms.

On Oct. 31, 2014, high school students in Chicago were also using methanol to create a green flame inside a pumpkin when it exploded.[6] At least one student was injured.

In April 2015, a teacher in the UK demonstrated the burning of liquid methane by pouring it onto the floor of the classroom.[7] Fortunately, no one was injured.

Calais Weber was 15 years old when her chemistry teacher poured methanol from a 4-L bottle onto an open flame during a flame test demonstration in 2006. Weber suffered burns over 40% of her body.[8-10]

"I came very close to dying from my injuries," Weber said at an Oct. 30 press briefing about CSB's new safety bulletin. "My greatest fear is that eventually there will be a child [who] won't be as lucky as I was to have survived."

> On chemical demonstrations, Ms. Weber takes a harder line than CSB. She said:
> "It is my belief that until there exists a standard mandatory protocol for training all science teachers, there is no reason for methanol to be used in classrooms. My education and love for chemistry were not fostered by seeing a demonstration in person, and it would not have been hindered by simply watching a video of it being performed in a controlled setting by trained chemists"

There are many more such accidents and injuries summed up by Samuella B. Sigmann in an article in the Journal of Chemical Edeucation.[11]

The problem in many of these demonstrations is blamed on methanol. As a result, calls went out to ban methanol from all chemical demonstrations. Why methanol? There are two major areas of concern. First, methanol burns with a pale blue flame. (see Figure 2.) In normal room light, that flame may not be very visible, so the demonstrator may not observe the methanol is burning when attempting to add additional fuel. The major problem is due to its high vapor pressure. Using a large container partially filled with a flammable liquid, such as methanol, can result in flame jetting.[12] This is where the air-vapor mixture in the bottle ignites sending burning liquid into a room. Even a small volume of methanol, in an open container, such as a beaker or evaporating dish, can build up sufficient vapor concentration in a short time that it ignites with a flash and small vapor explosion.

Figure 2. A methanol flame. Photo by David A. Katz

These are not reasons to ban methanol from the classroom or from chemical demonstrations, but they are hazards that a demonstrator must be aware of. Should a demonstrator use methanol in a demonstration where it is to be ignited, it should be poured from a small container almost immediately before use. If it is to stand of a period of time, the container should not have a large air space where the vapors can build up and the container must be covered. Depending on the demonstration, it may be appropriate to substitute ethanol or isopropyl alcohol (2-propanol) for methanol.

The Ugly

This is where individuals attempt to do spectacular demonstrations that put themselves and others at risk.

Sodium, and sometimes potassium, reactions with water have resulted in explosions used for “entertainment”. There are numerous photographs and videos on the Internet.[13-16]

Lithium, sodium and potassium can be handled safely in small quantities. With a freshly cut surface, the demonstrator can show the conductivity of the sodium metal. (see Figure 3)

To show the reaction of alkali metals, lithium, sodium and potassium, with water this author has used a small piece of the metal, about 1to 2 grams, and approximately 200 mL of water in a 600 or 800 mL beaker covered with a fine mesh wire gauze. (see Figure 4) The wire mesh traps any sparks and allows the reaction gases to escape. The reaction is projected on a large screen or a white wall in the classroom. Note: Alkali metals should be stored in heavy mineral oil or paraffin oil such as Nujol.

Figure 3. The conductivity of sodium metal.
Photo by David A. Katz

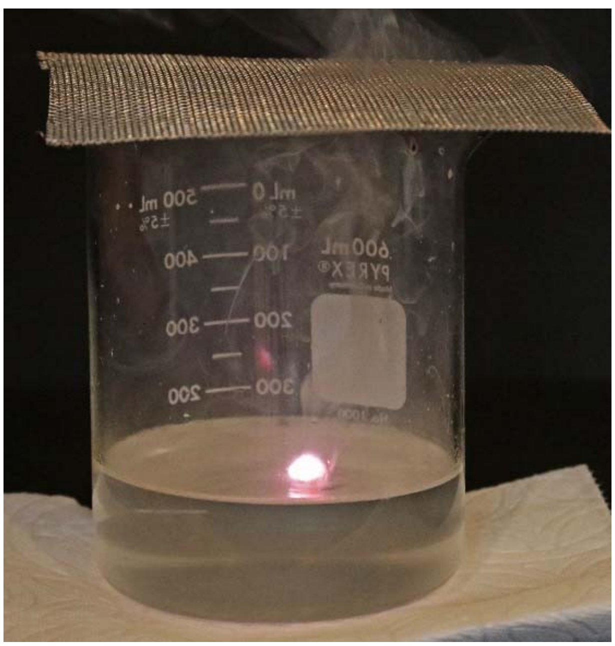

Figure 4. The reaction of potassium with water.
Photo by David A. Katz

Nitrocellulose, gun cotton, used by professional magicians in the form of flash paper or flash cotton, is another demonstration which can be misused. This author has observed a student affiliate chapter of the ACS, at a major University, line a large chalkboard with department made gun cotton as part of their demonstration show. On the television show TOSH.O, they did a number of what this author considers, inappropriate activities, using flash cotton which culminated with Daniel Tosh wrapping his private parts with the material.[17] This author advocates against using large quantities of nitrocellulose as well as attempting to prepare it in the laboratory. His preference is to purchase flash paper, in the form of sheets, or even dollar bills, or as flash cotton from reputable magician supply companies. Small amounts of flash paper or flash cotton can be used relatively safely in properly planned demonstrations.

Exploding bottles, especially PET bottles, filled with dry ice, or even liquid nitrogen, are especially dangerous. Glass bottles result in pieces of glass that can be propelled over a wide area. PET bottles, used to replace glass bottles for carbonated beverages, are constructed in layers that make them especially strong under pressure. Never use a screw cap on a bottle, glass or PET, containing dry ice or anything that can result in a large build-up of pressure, a large explosion may result.[18-20]

The methanol cannon demonstration shows how much chemical energy is released from a small quantity of fuel. It is often performed using methanol or ethanol in plastic bottle 500 mL to 1 Liter in size.[21] To be performed safely, the methanol cannon should be carried out in a plastic bottle, preferably taped to insure that the bottle doesn't split open. The bottle should be clamped and behind a safety shield rather than hand-held. The bottle should be sealed with a cork, rather than a rubber stopper, and pointed away from all spectators. (While both a cork and a rubber stopper can be dangerous projectiles, a cork is not as hard as a rubber stopper.) Only after the bottle is corked, should the igniter be attached. This prevents any sparks when adding the methanol. Should the demonstrator attempt to repeat this demonstration, they should use a different bottle as the first one may be hot enough to ignite the methanol or may contain a small residual flame from the excess alcohol.

The methanol canon has graduated to the whoosh bottle which uses a large water dispenser bottle with a volume of 16 to 20 Liters.[22-24] This demonstration was originally done in glass bottles, but they were replaced with safer polycarbonate bottles. Polycarbonate bottles do have a limited life for this experiment as the fire will deplete plasticizer from the bottle, eventually making it brittle. It is recommended that isopropyl alcohol (2-propanol) be used as the fuel for the whoosh bottle.

Exploding a hydrogen-filled balloon is dramatic. There are many images and videos on the Internet, some include mixtures of hydrogen and oxygen, some disregard proper safety precautions.[25] It is particularly important to warn the spectators to cover their ears as there will be a loud sound, especially with a hydrogen-oxygen mixture. Even with proper safety precautions, there is no reason, in this author's opinion, to explode more than 30 hydrogen-filled balloons.[26] There is also an incident where hydrogen filled balloons were used at a birthday party with the birthday girl suffering major burns.[27] On a small scale, hydrogen gas can be generated into a test tube. If air is present, mixed with the hydrogen, there will be a "pop" from the small gas explosion. Burning almost pure hydrogen in a large test tube and observing the water condensed on the inner walls of the tube is a learning experience. (see Figure 5.)

Figure 5. Burning almost pure hydrogen.
Photo by David A. Katz

The Thermite process was developed by Hans Goldschmidt in 1893. One of the immediate uses of this reaction was to weld two pieces of metal together, particularly railroad tracks. Thermite is cited in many chemistry textbooks, with photos, as an example of an exothermic reaction. There have been numerous accidents and injuries as a result of improperly set up Thermite reactions. In 1990, 23 students were hurt when the molten iron from a Thermite reaction exploded in a large beaker of water.[28] In a personal conversation with this author, the demonstrator stated they normally used dry sand in a glass beaker to catch the molten iron, but someone suggested adding water to the beaker for this particular demonstration. It was not stated how much thermite mixture was used.

There seems to be a lot of fascination with Thermite reactions in pumpkins for Halloween. A video by Glen Tickle has been uploaded by the Royal Institution.[29]

Directions for the Thermite reaction was published in *Education in Chemistry* by Adrian Guy in 2010.[30] Guy uses 16 g of Thermite mixture. The molten iron is collected in a 1-L Beaker filled with sand to 200 mL and water to 800 mL. In correspondence with this author, Guy claimed that the small amount of iron produced does not present a problem in the water and allows him to pick up the iron nugget after a short time so he can display it to his class. This author stated that the molten iron from a Thermite reaction should never be directed into water. If one wishes to show the iron to a class, use a nugget from a previous Thermite reaction and it can be passed around for students to handle. While Guy's publication contains safety precautions for the demonstration, it does not warn against using larger quantities of Thermite.

This author strongly recommends that a metal bucket filled with dry sand should be the proper container to catch the molten iron from a Thermite reaction.[31]

No Documented Accidents

This author did not find any documentation for accidents from some popular demonstrations/activities, but has concerns for their safety.

The electric pickle demonstration shows the conductivity of a sodium chloride solution in a pickle with the emission of a sodium spectrum. All too often, the pickle is powered by electricity from a 120 volt AC circuit with no shut-off switch.[32] Another version, properly set up with the pickle elevated from the benchtop, still has no way to turn off the electricity other than pulling the plug from the socket.[33] For safety purposes, there should be a momentary switch in the circuit so that the power is turned off when the switch is released. In addition, the power cord used should be long enough to keep the demonstrator a safe distance from the reaction.

Conductivity testing in the laboratory often uses a light bulb in a 120 volt AC circuit with no shut-off switch. Again, the apparatus should have a momentary switch to shut off the current when the switch is released. A safe conductivity apparatus was designed by Courtney Willis (University of Northern Colorado) and this author using two LEDs and a 9-volt battery. This battery-operated tester can be safely used by students at any grade level.[34]

Elephant's toothpaste has been a popular demonstration of the rapid catalytic decomposition of hydrogen peroxide producing copious amounts of foam. Originally utilizing 30% hydrogen peroxide, potassium iodide, food color, and a dishwashing detergent solution, hazards included burns from the hydrogen peroxide, heat from the reaction, and any unreacted hydrogen peroxide in the resulting foam. In addition, the foam contains bubbles of oxygen gas which supports combustion of flammable materials. More recent recipes call for 6% hydrogen peroxide which can still produce burns. Internet photos show people, often youngsters immersing their bare hands into the foam. Unfortunately, there are individuals who want to create ever bigger reactions.[35] While almost all the procedures recommend wearing safety glasses or goggles, this author recommends that gloves and a lab coat, apron, or other protective clothing are required for performing this demonstration.

Elephant's toothpaste can be carried out relatively safely using 3% hydrogen peroxide, yeast, dishwashing detergent and food color. Proper PPE should be worn.

Chemistry Uses Chemicals

Every chemical has some degree of hazard, although some are essentially negligible. As a chemist, this author, as well as many others, were trained in the proper handling and use of a wide range of chemicals.

Don't ban chemicals because they are flammable or corrosive – each chemical must be evaluated for the demonstration, any vapors produced, and disposal hazards. A responsible demonstrator must read the SDS, or at least Google the properties and potential hazards for each chemical used. When reading the SDS, the demonstrator must note both the acute and chronic effects of each chemical. For a demonstration, this may be for the audience, a one-time exposure to that chemical, so the acute hazard is most important. For the demonstrator, depending on how often that chemical is used, the chronic effect gains importance.

Don't ban a demo due to inexperienced demonstrators. Demand that presenters are properly trained in handling of materials and demonstration techniques, have the proper safety equipment nearby, and know what to do if something goes wrong.

Active Learning

A report by Scott Freeman and colleagues in the Proceedings of the National Academy of Sciences[36] reported that students get better grades and fail less when professors use active-learning methods in the classroom.

Active learning in the classroom can utilize a number of methods including demonstrations, mini-experiments, active hands-on activities, clickers, small group discussions, and more depending on an instructor's methodology. As previously stated, this author has done demonstrations and hands-on activities in the classroom throughout his career.

Demonstrations and hands-on activities can be an effective teaching tool when integrated into the curriculum. While there can be a great deal of entertainment value to a demonstration, or a series of demonstrations, each demonstration or activity should have some educational value. Hands-on activities should be appropriate to the age group and the capabilities for handling of materials and apparatus of the audience. It is the role of the teacher-demonstrator to explain the principles to the audience so they can understand what they observed and to guide them to discovery.

Safety Guidelines for Demonstrations

The ACS Division of Chemical Education has published *Minimum Safety Guideline for Chemical Demonstrations* for many years. In 2018, these were updated to *Safety Guidelines for Chemical Demonstrations.*[37] These updated guidelines are a vast improvement over previous versions. The reader, however, must have a knowledge of chemical safety, something that many teachers do not have and have not been part of their education.

The National Science Teachers Association also has their *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops* for all hands-on demonstrations, experiments, and workshops given at NSTA-sponsored events in rooms, other on-site locations, and on the floor of the NSTA exhibit hall.[38] Since NSTA encompasses all fields of science, these guidelines cover a broader area than those of the ACS.

Flinn Scientific has a history of over 40 years of safety information, initially as part of their catalog of science supplies and apparatus, and now, online safety reference articles and videos.[39]

The ACS Committee on Chemical Safety (CCCS) has published two books: *Safety in the elementary School Classroom*, and *ACS Safety Guidelines and Recommendations for the Teaching of High School Chemistry*. These can be downloaded at no cost from the ACS website.[40]

Where does one learn chemical demonstrations?

Safety guidelines are certainly important, but they do not teach how to do chemical demonstrations.

Chemical demonstrations have historically been observed and shared between peers at conferences such as ChemEd, Biennial Conferences on Chemical Education (BCCE), International Conferences on Chemical Education (ICCE), The National Science Teachers Association (NSTA), and regional conferences. Some schools have student groups and/or ACS Student Affiliate Chapters that do demonstrations in local schools, shopping malls, and other venues particularly for National Chemistry Week and/or Earth Week.

At a number of early ChemEd conferences, in the 1970s, held at University of Waterloo, Waterloo, ON, safety presentations, sometimes presented by the Canadian Fire Department, were part of the program.

Most presenters are responsible and observe proper safety precautions. Some presenters are not, sometimes pushing for the "WOW!" factor in their demonstrations.

In the 1980's there were programs that taught chemical demonstrations. Generally supported by grants, these included the Institute for Chemical Education (ICE), Hope College, and Dreyfus Institute. Unfortunately, as grant funding dried up, these programs have not continued.

Some journals (*J. Chem. Educ.*, *Education in Chemistry* (RSC), and those from NSTA) include chemical demonstrations. The RSC has a website of Practical Resources containing experiments, simulations, and demonstrations.[41] They also have a number of YouTube Videos which contains many demonstrations and experiments.[42]

Some schools do have science methods courses and teach demonstrations to prospective teachers. The amount of demonstration experience varies from as few as one or two demonstrations to many during such courses. During his tenure at Cabrini College in Radnor, PA, from 1991 through 1998, this author and a colleague, from the science education department, had prospective teachers work through approximately 50 chemical demonstrations during a one semester course. A positive result of that course was that those teachers took demonstrations into their field service classrooms each week.

Flinn Scientific, as noted previously, has produced both safety and demonstration videos.

There is no current national program that teaches chemical demonstrations and proper demonstration techniques.

Sources of chemical Demonstrations

The *Journal of Chemical Education* has published chemical demonstrations since Volume 1 in 1924. Hubert Alyea edited the series *Tested Demonstrations* starting in 1955-56. In subsequent years, *Tested Demonstrations* were edited by Frederic B. Dutton, Dale Dreisbach, and George Gilbert. *Tested Demonstrations* were compiled in several editions of *Tested Demonstrations in Chemistry* published through the ACS Division of Chemical Education. (These volumes are out of print and are difficult to find.) Safety information was minimal in these publications. George Gilbert compiled and updated *Tested Demonstrations in Chemistry and Selected Demonstrations from the Journal of Chemical Education* in two volumes in 1994. (Also, out of print.) The safety information, improved in these volumes, were still somewhat minimal at the time of publication.

This author published an extensive list of demonstration books in this journal in 1991.[43] Unfortunately, with the explosion of science videos, TV shows, and Internet listings and videos, that list has not been updated.

Some books such as Shakashiri's *Chemical Demonstrations* present detailed descriptions of demonstrations in a scholarly manner with complete explanations and safety precautions which were appropriate at the time of publication.[44-48]

Theodore Grays' *Mad Science: Experiments You Can Do At Home – But Probably Shouldn't* [49] and *Mad Science 2: Experiments You Can Do At Home, But STILL Probably Shouldn't* [50] contain spectacular photographs of demonstrations with, what this author considers, minimal safety information. The photographs influenced individuals to attempt some of these experiments and posting them on the Internet.

YouTube videos. TV shows such as *America's Funniest Home Videos*, and even TV news shows often show home-made or YouTube videos. Many of these without adequate instructions and implicit safety precautions encourage, in this author's opinion, stupidity.

Why some demonstration books, YouTube, or TV videos are dangerous

Most demonstrations books do have lists of materials needed and a set of instructions. Most online videos offer little or no instructions and, often, just a list of materials and/or a narration from the experimenter. They contain little or no safety guidelines or outdated safety information. Chemicals are not always measured. There is often no clean-up or disposal information. Non-informed viewers will try to duplicate "cool" demos, sometimes scaling up the quantities, for the "WOW!" factor, and not understanding that bigger is not better. When asked about any problems, the response is "Accidents don't happen to me" or "We never had a problem."

What the safety guidelines, many books, and most videos don't tell you

- Safety shields may be required.
- Use small quantities of chemicals and flammable liquids.
- Pre-measure chemicals. Have just enough chemicals for the demo or activity in appropriate size containers.
- Never pour from bulk containers.
- Close containers after measuring or pouring chemicals.
- Move containers away from the demo.
- All materials, whether used for that demonstration, or another one, must be placed at a safe distance from the current demo.
- Keep a back-up supply if needed.
- Repeat any demo from the start – do not try to replenish a reaction in progress.
- Small may be better – just project it onto a large screen

Guidelines for successful demonstrations

Know what you are working with. Read and understand the SDS. Be aware of both acute and chronic health hazards of chemicals used.

Use proper laboratory glassware (*e.g.,* borosilicate glass).

Inspect all equipment and apparatus, especially glassware, for cracks or chips.

Know that hot plates can spark internally and can ignite flammable vapors.

When doing demonstrations, materials must be organized. Small trays are useful to keep materials for each demonstration together.

Make sure there is proper ventilation for the demonstration. Be aware of smoke detectors if flames are used.

Practice your demo, in advance, in a safe location.

Organize your demonstration materials before your presentation. Premeasure all your materials in appropriate size containers. If possible, spread them out on a table in the order you will use them. At this point, all containers must be sealed or covered.

When you do a presentation, you should remove all unnecessary material from your podium or tabletop. Likewise, when you are doing a demonstration, place the materials on a table or stand where your audience will have a good view of the apparatus. If you are using a flammable substance, such as an alcohol, do not pour it into the reaction container until just before use. After your setup, move everything else out of the way.

When using a volatile and flammable liquid:

- Pre-measure the amount needed in a separate container. If you think you may need a back-up, have the additional liquid in a small size, appropriately sealed, container.
- Keep it covered.
- Do not allow it to stand in the open air for any period of time, especially if it is to be ignited or if flames will be used nearby.
- Do not try to add additional flammable or reactive material to a reaction in progress.

If a demo does not work, make sure there is no possibility of any fire or reaction. Move everything to a safe location. Start fresh.

Bigger is not better. Reactions work different when quantities are changed or increased. Not all reactants are consumed when a reaction is multiplied. (Understand the kinetics involved.)

Repeat, the demonstration, if necessary, to illustrate principles being taught, not just for "fun" (*e.g.,* multiple hydrogen balloon explosions).

Things can go wrong, no matter how well you prepared – make sure that all necessary safety materials are available and that you know how to use them.

Eye protection is mandatory for the demonstrator, for any assistants, AND audience members near the demonstration. Splash goggles are preferred. Proper fit is required. Have a range of goggles available from small size to regular adult size. Goggles must be clean. Note: Goggles and safety glasses are best cleaned with soap or detergent and water.

Gloves are not necessary for every demonstration. The need for gloves can be determined from the SDS. Gloves must have a good fit and provide good dexterity for handling all materials. Gloves must be appropriate for the materials being used. While latex or nitrile gloves should be adequate for most materials in demonstrations, check glove compatibility data or charts.

Gloves must be changed when contaminated.

Lab coats or aprons protect the demonstrator and any workers from minor splashes. Fireproof lab coats are available. They are more costly than most standard lab coats, but, are cost effective if the demonstrator works with flammable materials.

Lab coats must be properly laundered. Just detergent, no fabric softeners.

Contain apparatus to prevent, or minimize, spills. Not every spill is a large one. (see Figures 6 and 7.)

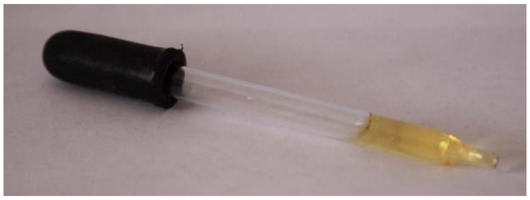

Figure 6. This is a small spill.
Photo by David A. Katz

Figure 7. This is a way to contain a possible small spill.
Photo by David A. Katz

Clean up spills promptly. Have the proper materials to clean up any spill from a few mL in size to a larger spill. If all materials are properly premeasured, a large spill will most probably be unlikely.

Electric circuits used in any demonstration must have an on/off switch.

Don't pass anything that is potentially hazardous around the room.   In 2008, a student at a Summer Enrichment Program drank some liquid nitrogen from a foam cup which was passed around the classroom.[51] Reports of other incidents with liquid nitrogen used for molecular gastronomy cocktails can be found on the Internet.

Small samples should be sealed in vials which can be secured with heat shrink tape or tubing. Liquids are best sealed in glass ampules and then in vials. Liquified gases or solid carbon dioxide (dry ice), which can build up high pressure at room temperatures, should never be placed in sealed containers to be handled by anyone.

Storage of demonstration materials

In most situations, you do not have sufficient space and materials to store complete demonstrations.

Using small containers, store only the essential items that are unique to that demonstration. Chemicals, however, must be stored in proper shelves or cabinets. Include the directions for doing the demonstration with the stored items.

Maintain a list of materials needed for each demonstration, you should be able to gather them from your regular classroom or laboratory supplies.

Include safety information with your list of materials needed for each demonstration. This must include directions for cleaning up any spills and what to do if something goes wrong. These may be abbreviated copies of the SDS for each chemical.

Have containers or bottles for chemicals and solutions clearly labeled with the labels protected by clear, waterproof tape, such as shipping tape. Since these bottles are secondary containers, they are not required to be labeled as primary containers. They must, however, have proper warning words such as caustic, corrosive, flammable, etc…, on their labels. CAUTION: Never use containers that were once used for food materials such as baby food jars or soft or fruit drink bottles. If anyone ingests any materials from a former food contain and becomes ill, or worse, there is no lawyer who can save you from the liabilities incurred.

All storage containers should be of manageable size. Do not bring 4-Liter size bottles of liquid or solution if you only need 100 mL (or less) of the liquid or solution. Concentrated acids and bases should be in the smallest container that contains the quantity needed for the demonstration or activity.

Moving demonstrations to your presentation site

Set the demonstration materials in a large tray or container (primary containment) on a rolling cart and roll it around your room or laboratory or to another classroom.

Use small plastic wash basins (rectangular shape preferred) or similar containers, to hold materials for each separate demonstration or activity inside the large tray (secondary containment). This keeps everything together and provides some safety in case of a spill during transport.

If moving to another floor in a building, use a freight elevator, if available. If not, use an elevator that is not occupied by other individuals. Only the individual transporting the materials should be on the elevator. At least one other individual should be on the floor where the elevator is traveling to whenever possible.

Use plastic (unbreakable) and/or safety coated bottles for chemicals whenever possible.

In summary

YES, you can do the Rainbow Flame demonstration. Before attempting this demonstration, the demonstrator must be aware of all the possible hazards and have the proper set-up. It is important that the demonstrator view the RSC procedure and video.[52] The RSC video does show the proper set-up for the demonstration using 250-mL beakers. They recommend using ethanol in place of methanol for the demonstration. The demonstrator must be aware that the beakers get hot and should be well insulated from the surface where they are placed by using ceramic fiber boards or similar insulating material. Beaker tongs must be used for handling the hot beakers after the reaction.

Summing up: Safety with demonstrations and activities

- Safety doesn't mean that things don't go wrong.
- Safety means that all necessary precautions are taken to minimize any risks.
- Safety means that the demonstrator knows what he/she is doing.
- Safety means that the demonstrator is familiar with the properties of the substances they are working with.
- Safety means that all apparatus is inspected for any cracks, chips, or imperfections before use.
- Safety means that all necessary demonstrations are tested and all materials are measured and prepared in advance.
- Safety means that all materials are properly transported to the site of the demonstration or activity.
- Safety means that the appropriate PPE are worn for the demonstration or activity.
- Safety means that all appropriate safety equipment is readily available. (i.e., fire extinguishers, spill clean-up materials, etc.)
- Safety means that all demonstrations are appropriate for the venue where they are presented.
- Safety means that all hands-on activities are appropriate for the age group and abilities of the audience.
- Safety means that there should be assistants, familiar with the activities and safety, to assist with hands-on activities whenever possible.
- Safety means that any potential problems (i.e., vapors, sparks, projectiles, etc.) are contained.
- Safety means that no one, including the demonstrator, is injured or put at the risk of injury.
- Safety means that the facilities (i.e., the classroom, lab, furnishings, etc.) are not damaged.
- Safety means that all waste materials are properly handled and disposed of.

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