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P.O. Box 219 • Batavia, IL 60510
(800) 452-1261 • Fax (866) 452-1436
www.flinnsci.com • E-mail: flinn@flinnsci.com
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Acid Safety

Safety Tips for Using Acids in School Laboratories

Introduction

The use of acids is an important component of most chemical laboratories. Understanding the properties and hazards of acids are important initial steps to safe purchase, storage, use, and disposal of acids.

Properties

Acid	Formula	F.W. g/mol	Specific Gravity	Concentrated Acid	
				wt% Acid	Molarity
Acetic	$\text{HC}_2\text{H}_3\text{O}_2$	60.05	1.05	99.8	17.4
Hydrochloric	HCl	36.46	1.19	37.2	12.1
Nitric	HNO_3	63.02	1.42	69.5	15.8
Phosphoric	H_3PO_4	98.00	1.70	86	14.8
Sulfuric	H_2SO_4	98.08	1.84	96	18.0

Safety Precautions

Concentrated acids are strongly corrosive to all body tissue, especially eyes and skin. Concentrated acids are highly toxic due to their extreme corrosiveness. Hydrochloric and acetic acids are also toxic by inhalation. Other hazards are presented in this review. Always wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron whenever using concentrated acids or acid solutions. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Purchase

- Purchase dilute acids whenever possible. Dilute acid solutions are safer, and easier to handle, use, and store than concentrated acids. They will also save valuable prep time.
- Purchase small quantities of acids to help keep your acid fresh and to make storage and handling safer and easier. It is easier to clean up a 100-mL than a 2.5 L acid spill.
- Always purchase concentrated acids in PVC-coated glass bottles. PVC-coated bottles will not shatter and spill acid when dropped. The PVC creates a plastic envelope around the bottle that greatly reduces spills and breakage. The PVC coating may discolor over time, especially when exposed to hydrochloric acid fumes. This discoloration does not affect the PVC coating or the quality of the acid inside the bottle.

Storage

- Store all acids in a dedicated corrosives or acid cabinet. The best acid cabinets are built with wood because metal cabinets will quickly corrode from acid fumes. Wood cabinets will provide years of safe and durable acid storage. The cabinet should be located in a locked chemical storeroom. If not, the cabinet must be secured with a lock.
- Storing acids and bases together in one corrosive cabinet is acceptable. However, the bottles may become covered with ammonium chloride from the hydrochloric acid and ammonia fumes. The cabinet and bottles should be washed with TSP or other strong cleaner to remove the white film.

- If an acid cabinet is not available, store concentrated acid in Saf-Stor® shipping cubes. A Saf-Stor cube will provide good secondary containment and protection.
- Label all prepared acid solutions before storing them with at least the name of the acid, its concentration, a hazard warning or how the acid can hurt you, and the date prepared on the label.
- Always keep the appropriate color-coded acid bottle cap on the concentrated acid bottle. Never use these caps on other bottles. Color-coded bottle caps provide an extra safety measure to identify concentrated acids if the label is removed or destroyed. If an acid bottle cap becomes cracked or discolored, always replace the cap with the proper color-coded cap. The following colors are used on all concentrated acid bottles sold in the United States.
 - Acetic Acid — Brown
 - Hydrochloric Acid — Blue
 - Nitric Acid — Red
 - Phosphoric Acid — White
 - Sulfuric Acid — Yellow
 - Ammonium Hydroxide — Green
- Concentrated **hydrochloric acid** fumes continuously and cannot be stored without releasing hydrochloric acid fumes. These fumes are responsible for most of the corrosion damage in your chemical storeroom. Storing hydrochloric acid in a wood acid cabinet is a must. Hydrochloric acid fumes will quickly corrode metal cabinets.
- **Nitric acid** is a strong oxidizing agent. Concentrated nitric acid must be stored in a separate liquid-tight compartment within an acid cabinet. If nitric acid is mixed with a flammable organic compound, such as acetic acid, the heat from the oxidation and neutralization reactions is enough to ignite the flammable material. Nitric acid also slowly destroys its red plastic bottle cap. Always replace with a new red cap. Nitric acid may also turn yellow over time because of the release of nitrogen dioxide on exposure to light. The yellow color does not affect the product's usefulness in the school laboratory.
- **Glacial acetic acid** is a flammable liquid. It should be stored in an acid cabinet, but in a location that is isolated from possible contact with nitric acid. Glacial acetic acid freezes at 16.6 °C; the material may crystallize in a cool storeroom. If this occurs, allow the bottle to warm up to ambient (25 °C) temperature.
- Concentrated **sulfuric acid** is a strong dehydrating agent. Because of its strong ability to remove water, it reacts violently with many organic materials such as sugar, wood, and paper. If sulfuric acid has turned brown, it has probably been contaminated with an organic material and its purity should be in question.
- Concentrated **phosphoric acid** has a melting point close to ambient temperature and may also crystallize in a cool storeroom. Phosphoric acid is hygroscopic and will absorb water over time. Keep tightly sealed.

Transporting

- Secondary containment is critical to prevent major spills or accidents when transporting acids. Use PVC-coated acid bottles or unbreakable bottle carriers.
- A good habit is to check the acid bottle for cracks before touching or picking it up. Also check for spilled acid on the handle or bottle.
- Always carry 2.5-L acid bottles with one hand underneath the bottle and the other hand around the neck or finger hole. This keeps the bottle closer to your body and decreases the risk of hitting a sharp object, like a desk corner, and breaking the bottle.
- Plastic or rubber safety bottle carriers should be used whenever acids are transported from one laboratory to another or from the storeroom to a laboratory.
- If a cart is used to transport hazardous chemicals, such as acids, place compatible chemicals inside an unbreakable secondary containment vessel, such as a plastic tote. The cart should be equipped with guardrails to prevent plastic totes or bottles from sliding off the cart.
- If hazardous chemicals are moved from one floor to another, use an elevator if possible. Only the teacher transporting the chemicals should be on the elevator. Although elevator accidents are rare, should a dangerous material be released in an elevator while passengers are trapped inside, the results could be catastrophic.

Preparation of Acid Solutions

Determine the proper recipe using Table 1 or Equation 1.

Table 1. Milliliters of concentrated acid needed to prepare one (1) liter of solution

Acid	Molarity	0.5 M	1.0 M	3.0 M	6.0 M
Acetic	17.4 M	28.7	57.5	173	345
Hydrochloric	12.1 M	41.3	82.6	248	496
Nitric	15.8 M	31.6	63.3	190	380
Phosphoric	14.8 M	33.8	67.6	203	405
Sulfuric	18.0 M	27.8	55.6	168	333

Equation 1 $M_1 V_1 = M_2 V_2 \rightarrow$ where M = Molarity and V = volume

Example: To prepare 600 mL of 2.5 M HCl from concentrated HCl $12.1 \text{ M } V_1 = 2.5 \text{ M (600 mL)}$

$$V_1 = 2.5 \text{ M (600 mL)} / 12.1 \text{ M}$$

$$V_1 = 124 \text{ mL}$$

Therefore, 124 mL of HCl (conc) is diluted with enough water to give a final volume of 600 mL

To Prepare a Solution

1. Add the appropriate amount of acid to about 2/3 of the required amount of distilled or deionized water.
2. Always add acid to water! Never add water to concentrated acids. The acid may splatter and generate acidic steam.
3. Always use borosilicate glassware.
4. Stir to mix the solution.
5. Once the solution has cooled to ambient temperature, dilute the solution to the proper volume with water.
6. Use a volumetric flask for extra precision.
7. When diluting sulfuric acid, place the borosilicate beaker or flask in an ice bath. The heat of dilution of sulfuric acid is very high and may melt plastic containers or crack non-borosilicate glassware.

Using and Dispensing Acids

- Always review the Materials Safety Data Sheet (MSDS) before using any hazardous material in the laboratory.
- Students should dispense acids from smaller bottles to limit spills and fumes.
- Use lab mats and or plastic trays when dispensing acids to contain acid spills and drips.
- Dispense acids, especially hydrochloric, nitric, and acetic acids, in an operating fume hood.
- During lab, set the acid bottle in a central dispensing location and have students bring a graduated cylinder or test tube to the dispensing area. This will help to minimize spills and accidents as well as limiting the amount of acid being transported back to the lab bench.
- Instruct students to only remove the amount of acid needed for the experiment from the reagent bottle. Chemicals are never added back to the reagent bottle.
- Have acid spill clean-up materials readily available whenever acids are used.
- Acids are corrosive and will eat through most fabrics, resulting in small holes in clothing. This process does not occur instantly but rather over several hours and may not become apparent until the clothes are washed. Always wear a chemical-resistant apron or laboratory coat when working with acids.

Personal Protection Equipment and Safety Aids

- Nitrile rubber gloves are acid-resistant and are the best choice to use when handling concentrated acids. However, any plastic or vinyl glove will provide some protection against the occasional splash, small spill, and splatter that may occur when using or dispensing acids.
- Operating eyewashes must be available in any classroom or laboratory where acids or acid solutions are used. An approved eyewash must treat both eyes and provide clean potable water for at least 15–20 minutes.
- Chemical splash goggles must be worn whenever acids or acid solutions are used. Safety glasses are not adequate protection.
- Good ventilation should be available whenever hydrochloric, nitric, or acetic acids are used.
- Spill control materials (sand, absorbent, and neutralizer) must be available whenever acids or acid solutions are used.

First Aid

- Always seek professional medical attention upon exposure to any hazardous chemical, especially concentrated acids.
- The best first aid for any chemical exposure to body tissue or eyes is immediate dilution with water.
- If an acid is splashed in the eyes, use an eyewash to irrigate the eyes for at least 15–20 minutes. Make sure the eyelids are held open to properly irrigate them. Ask the victim to look up, down, and sideways to better reach all parts of the eye.
- If an acid is splashed onto bare skin, rinse with water for at least 15–20 minutes.
- If an acid is splashed onto clothing, consider removing the clothing immediately before the acid soaks through the clothing and reacts with the skin. If an acid splashes onto your skin and clothing, immediately begin rinsing the affected areas with water (safety shower is ideal) and then begin to remove affected clothing. Modesty must take a back seat to the potential chemical burns that can occur.
- If acid is ingested, the primary goal is to dilute the acid in the stomach and prevent further injury caused by vomiting. If the victim is conscious, immediately have the victim rinse their mouth out with water. Have the victim drink one or two cups of water or milk. Gastric antacids such as milk of magnesia or aluminum hydroxide can also be given. Do not induce vomiting, do not try to neutralize the acid with a strong base, and do not give the victim any sodium bicarbonate or any carbonated drinks. Call a poison control center or hospital emergency room and follow their directions.

Disposal

- Always dilute and neutralize all acids before disposal.
- Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. See Flinn suggested laboratory chemical disposal procedures #24a and #24b.

References

Flinn Scientific Catalog/Reference Manual

Lefevre, M. J. *First Aid Manual for Chemical Accidents*, 2nd Ed. Van Nostrand Reinhold: New York, 1989.

CRC Handbook of Laboratory Safety, 2nd ed.; Steere, N. V., Ed.: CRC: Boca Raton, 1971.