Hydrofluoric Acid (H+F-) What YOU need to know

Hydrofluoric acid is an aqueous inorganic acid solution commonly used in research and industry for its ability to etch silicon compounds. It is an essential tool for semiconductor and electronic fabrication, mineral processing and glass etching. In addition to its useful properties, hydrofluoric acid also poses severe health risks upon exposure. Best management practices must be reviewed and *continually* employed while working with this material.

The Technical Info:

Hydrofluoric acid (CAS#7664-39-3) is the aqueous form of hydrogen fluoride gas, miscible with water. Both versions are commonly referred to as HF in research and industry. It has a molecular weight of 20.01 and can typically be found in concentrations of 48-52% in water. Hydrofluoric acid is extremely corrosive! Aqueous solutions dilute as 0.1 M will pH at approximately 1.0. Unlike other mineral acids, hydrofluoric acid will attack glass, concrete, rubber, quartz and alloys containing silica.

Why So Dangerous?

Common mineral acids such as hydrochloric, phosphoric, nitric and sulfuric acid can cause surface burns when a dermal exposure occurs. The area affected is localized, in other words, only the area contacted by the acid is affected. The mechanism for the local tissue corrosion is caused by the active hydrogen cation (H^+) of the acid.

Hydrofluoric acid will also cause local injuries; however, it does not stop there. The fluoride anion (F^-) that dissociates from its hydrogen counterpart readily absorbs through the skin and performs its damage on the inside, penetrating deep into body tissues, causing a systemic injury.

The fluoride ion has an affinity for calcium and magnesium, two minerals that are essential for bodily health. As the fluoride binds with calcium, it consumes the body's supply of this mineral in the blood and also attacks bone structure, forming calcium fluoride salts.

As serum calcium levels are depleted in the blood, a condition known as hypocalcaemia, organ failure begins to occur, heart function becomes erratic and can eventually fail, obviously resulting in death.

An addition quirk of hydrofluoric acid is that dermal burns may not be readily noticed or painful, unlike the warning properties of other acids. Skin contact with HF concentrations in the 20% to 50% range may not produce symptoms for one to eight hours. With concentrations less than 20%, the latency period may be up to twenty-four hours. A solution of only 1-2% HF exposed to greater than 10% of your body is fatal without medical attention; however dermal burns are not likely immediate.

Moderately concentrated solutions of hydrofluoric acid (>40%) tend to fume and emanate hydrogen fluoride gas when exposed to air, producing yet another exposure risk through inhalation.

Signs and Symptoms of Exposure

Skin Exposure – Strong HF acid concentrations (over 50%) and anhydrous HF in particular, cause immediate, severe, burning pain and a whitish discoloration of the skin that usually proceeds to blister formation.

The usual initial signs of a dilute solution HF burn are redness, swelling and blistering, accompanied by severe throbbing pain.

Eye Contact – HF can cause severe eye burns with destruction or opacification of the cornea. Blindness may result from severe or untreated exposures.

Inhalation – Acute symptoms of inhalation may include coughing, choking, chest tightness, chills, fever and cyanosis (blue lips and skin). All individuals suspected of having inhaled HF should seek medical attention and observation for pulmonary effects. This includes any individuals with HF exposure to the head, chest or neck areas. If there is no initial upper respiratory irritation, significant inhalation exposure can generally be ruled out.

Ingestion – If HF is ingested, severe burns to the mouth, esophagus and stomach may occur. Ingestion of even small amounts of dilute HF has resulted in death.

What to Do if You Are Exposed to HF

Note: Time is of the essence as exposure to HF is a life-threatening emergency. Delay in first aid or medical treatment will result in greater damage or possibly death.

In all instances, as the victim is tending to the exposure, someone should call Public Safety at 911 or 258-3333 to arrange for transport to Health Services or UMCP.

Skin Contact

1. Speed and thoroughness in washing off the acid is of primary importance! Immediately start rinsing under safety shower or other water source even before removing contaminated clothing.
2. Flush affected area thoroughly with large amounts of water for 5 minutes.
3. Immediately after rinsing, begin one of the following treatments:
    a. Apply and massage 2.5% calcium gluconate topical gel onto the area of affected skin. Note: It is advisable for the individual applying the calcium gluconate gel to wear gloves to prevent a secondary HF exposure.
    b. Apply iced 0.13% Benzalkonium chloride (Zephiran®) solution soaks or compresses.
4. Receive professional medical attention immediately after initial treatment

Eye Contact

1. **Immediately** flush the eyes for at least 5 minutes with large amounts of gently flowing water.
2. Ice water compresses may be applied to the eyes while transporting the victim.

Inhalation

Immediately move victim to fresh air and call 911

Ingestion

1. Drink large amounts of water as quickly as possible to dilute the acid. Do not induce vomiting. Do not give emetics or baking soda. Never give anything by mouth to an unconscious person.
2. Drink several glasses of milk or several ounces of milk of magnesia, Mylanta®, Maalox®, etc. or grind up and administer up to 30 Tums™, Caltrate™ or other antacid tablets with water.

Personal Protective Equipment

Prevention is the best medicine indeed when working with a chemical as hazardous as hydrofluoric acid. Applicable in most but not all cases, the following personal protection garments should be utilized when working with HF.

- **Gloves** – Polyvinyl Chloride (PVC) or Neoprene gloves. Select a glove of suitable size to each individual wearer. Gauntlet style gloves are advised for working with large volumes or in cases where immersion of one's hand past the wrist is possible. Review the manufacturer's testing results of their gloves resistance to HF.
- **Shoes** – closed toe, leather or durable non-porous material. Rubber boots or over-boots are advised for large volumes.
- **Lab coat** – Rubber or impermeable material preferred, full-length and full arm construction.
- **Eyewear** – Chemical splash goggles at all times.
- **Ventilation** – Fume hood use is always advised.

The Princeton University department of Environmental Health and Safety (EHS) can be contacted in reference to recommended personal protective equipment and best management practices.

First Aid Treatments and Supplies

Environmental Health and Safety carries a stock of Calcium Gluconate gel in 25 gram tubes that can be obtained by campus labs for $24.00. Contact Jim Boehlert at 8-7882 or Boehlert@princeton.edu to acquire 2.5% calcium gluconate gel for your lab.

If you would like to order your own calcium gluconate, independent of Princeton University, the following distributors supply 2.5% calcium gluconate topical gel.

- Attard's Minerals, 5081 Field Street, San Diego, CA, 92110. http://attminerals.com/other_items.htm. Order attard@attminerals.com or phone 1-

619-275-2016. A 30-gram tube is $28 and a 60-gram tube is $46. There is no minimum to buy. Orders of 12 or more get a 15% discount. Orders up to 20 tubes have a $10 flat rate S&H charge. Attard's Mineral's regularly have a fresh supply of prepared gel.

- Pharmascience Laboratories, phone 1-866-570-4170.

Storage, Use and Disposal

Hydrofluoric acid attacks all silica containing materials, including glass. It must be used and stored in polyethylene (PE) bottles and vessels. Bottles for storage of HF must have secure caps and lids that can provide a gas-tight seal to prevent escape of hydrogen fluoride gas.

Hydrofluoric acid should never be disposed of by drain. Elementary neutralization of HF does not permit drain disposal, even if the resulting solution pH is 7. Neutralization of hydrofluoric acid with a basic material produces metal fluoride salts, which are toxic. It must always be collected as hazardous waste in closeable plastic containers.

Small spills of hydrofluoric acid (<100 mL) may be absorbed with a universal absorbent material such as Hazorb® or Chemsorb® spill pillows. Large spills of hydrofluoric acid (100mL to 4 L) must be soaked up with PowerSorb® or PolySorb® HF resistant spill materials as universal absorbents will degrade quickly. Be sure to have calcium gluconate gel and proper protective gear before responding to an HF spill. If the spill exceeds 4 liters, protective equipment or spill supplies are unavailable, contact Princeton University Public Safety at 8-3333 or EHS at 8-5294.

All materials that have been contaminated with hydrofluoric acid still exhibit a hazard and therefore should also be disposed of as hazardous waste. These materials include research devices, empty bottles formerly containing HF, spill debris and personal protection garments worn while using HF.

Further Information

A section of the Princeton University EHS Lab Safety Training Guide is devoted to hydrofluoric acid safety. It can be found online at:

http://web.princeton.edu/sites/ehs/labguide/sec_2e.htm#acid

Honeywell Incorporated is a major manufacturer of hydrofluoric acid. They have conducted extensive research and studied the effects of exposure to HF and how to prevent it. http://www.honeywell.com/sites/sm/chemicals/hfacid

http://membership.acs.org/F/FLUO/hfmedbook.pdf

Other references and resources:

http://www.calgonate.com/enCA//files/news1174416797.pdf

http://www.jtbaker.com/msds/englishhtml/H3994.htm