

University of Waterloo Hydrogen Fluoride Protocol

Description

Hydrogen fluoride (HF) is used at the University of Waterloo in various forms. Hydrofluoric acid comes in liquid form in various concentrations. It is clear, colourless, and resembles water. Anhydrous hydrogen fluoride is a gas at room pressure (1 atm) and temperature (20 °C). Regardless of its physical state or concentration, it is a highly toxic and corrosive substance with an irritating pungent odour.

Risks of Exposure

Exposure to concentrated HF will cause immediate death of live tissue accompanied with severe pain and burning. In dilute form its reaction can be delayed for up to 24 hours. Table 1 below outlines some of these key points.

Table 1: Contact exposure effects of HF based upon concentration.

Concentration	Time to onset of symptoms	Description of surface reaction	System toxicity
> 50 %	Immediate	Immediate burns, rapid destruction of tissue contacted, with severe pain.	Free fluoride ions aggressively bind to calcium, magnesium, and potassium creating insoluble salts. This loss of minerals in tissues and blood can cause many problems: <ul style="list-style-type: none"> • Interference with nerve impulses, muscle contraction and relaxation • Electrolyte imbalance leading to an irregular heartbeat or heart attack • Lowering of blood pH (metabolic acidosis)
20 % - 50 %	1 to 8 hour delay	Burns and destruction of tissue with pain	
< 20 %	Up to 24 hour delay	Redness, mild to severe pain, or potentially no surface reaction.	

Surface or contact reactions like burns, swelling due to liquid accumulation (edema), or skin death (necrosis) are not the only ones that occur. When HF dissociates, the fluoride ions begin searching for electrons by penetrating deep into body tissue. Their primary targets are calcium and magnesium.

As fluoride binds with calcium and magnesium, a deficiency of these minerals occurs in the body. Without enough calcium (hypocalcemia) and magnesium (hypomagnesemia), many tissue and organ functions become impaired. Furthermore, as calcium and magnesium are removed, potassium moves into the extra cellular space and fluid to compensate for the mineral loss. This causes irritation to the nerve endings resulting in pain and impairment of nerve impulse transmission.

Furthermore, an increase in the relative concentration of potassium increases (hyperkalemia) can lead to an irregular heartbeat which can lead to cardiac arrest.

Other modes of exposure include contact with the eyes, inhalation of fumes, and ingestion. The table below outlines some of the reactions associated with these modes of exposure.

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Table 2 lists health effects associated with other routes of exposure.

Table 2: Immediate health effects from various modes of exposure.

Route of Exposure	Immediate Reaction	Delayed Reactions
Eyes	<ul style="list-style-type: none"> • Severe burns • Opacity of cornea • Blindness 	<ul style="list-style-type: none"> •
Inhalation (lungs)	<ul style="list-style-type: none"> • Coughing/choking • Inability to breath/chest tightness • Chills/fever • Cyanosis 	<ul style="list-style-type: none"> • Laryngeal edema • Bronchospasm • Pulmonary edema • Respiratory arrest
Ingestion (mouth)	<ul style="list-style-type: none"> • Vomiting • Abdominal pain • Hemorrhage gastritis • Pancreatitis • Painful necrotic legions 	<ul style="list-style-type: none"> •

In many cases, exposure to HF in low concentrations is worse than at higher concentrations because exposures at lower concentrations result in delayed reactions (See table 1 above). This means a person may have been exposed without realizing immediate treatment is required. Therefore there is **SIGNIFICANT RISK** associated with the use of hydrogen fluoride at **ANY CONCENTRATION**.

NO CONCENTRATION is **SAFE TO HANDLE** without appropriate precautions.

Preventative Measures

Working with HF on campus is a high risk activity. The potential health consequences of misuse or mishandling are severe. For this reason we have outlined the following preventative measures for use with HF:

Planning

Before using HF in the lab determine if any suitable substitute can be found. If no substitute is available and HF is required for the work being undertaken, the **Safety Office recommends** the lab purchase or obtain access to Hexafluorine and Trivorex. Hexafluorine is a proprietary substance that immediately chelates the fluoride ion to reduce damage when exposure occurs.

Consider purchasing or obtaining access to (sharing access with another lab) if the lab:

- Uses HF more than 3 times per month
- Uses high volumes of HF (> 500 mL per use)
- Uses HF in a process that requires elevated temperature or agitation

the following minimum guidelines should be used:

- Development of safe work practices for procurement, storage, handling and use
- Ensure a **supplier specific** MSDS is available as a paper copy
- Documenting the safe work practices in standard operating procedures
- Anticipating emergency situations (accidental exposure, spills, etc...) and creating emergency procedures
- Identify and install or have available appropriate safety equipment (HF specific first aid and spill kits, eyewash stations, and safety showers)
- Training on all of the above for any individual using HF or who could come into contact with it.

These are explained below.

Procurement and Storage

- **PURCHASE** only the smallest volumes available for the work being performed. Do not purchase in containers larger than 2 L.
- **KEEP** an inventory of the HF used in the lab. Discard any HF that has not been used in 6 months. HF stored past 6 months should be taken to the Environmental Safety Facility.
- HF dissolves most metals, natural rubber, concrete, glass, fiberglass, ceramics and glazes. HF does not attack metallic lead and platinum, polyethylene, polypropylene, Teflon, Plexiglas (= acrylic), and wax.
- **STORE** HF in tightly closed containers made of polyethylene, Teflon, or fluorocarbon plastic. Use a polyethylene tray as secondary containment.
- **SEGREGATE** away from other chemicals, and metals.
- Limit access to HF by keeping in a controlled access area or a locked cabinet

Handling and Work Practices (The following serves as guidance for the development of lab specific operating procedures for handling and use of HF – EACH LAB SHOULD DEVELOP THEIR OWN SOPs)

- **DO NOT USE Hydrogen Fluoride** when working alone or outside regular business hours (8 am – 4:30 pm).
- **DO NOT** work with HF until you have received practical training on all the of the specific work procedures of your particular laboratory (or work space) that use HF. This should be performed by someone knowledgeable in the use and hazards of HF. This includes your supervisor, a lab technician, or senior graduate student.
- **BEFORE** using any HF, inspect the container to ensure it is not defective or damaged. If damaged, do not use and contact ext. 35755 for disposal instructions.
- Use the following PPE when using HF:
 - **Goggles**

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- **Face shield** (plastic)
- **Gloves:**
 - Thin disposable gloves (such as 4, 6, or 8 mil blue Nitrile glove) used in laboratory operations provide a contact barrier only and should be disposed of immediately when contamination is suspected. **ONLY** wear disposable gloves if you have double gloved.
 - Thicker (10-20 mil) PVC or neoprene gloves provide good resistance to HF but do not provide the necessary dexterity for most lab procedures.
 - A combination of double gloves, Nitrile and poly, can be used to provide greater protection from a broader range of materials (ie. If you are using other hazardous materials in your work).
- **Acid resistant apron**
- **Long pants, long sleeves, and closed toe shoes** (always required when working with corrosives)
- Use only in a fume hood.
- Syringes should be of a compatible material for HF, this means no metals or glass.
- **LABEL** and make a waste HF container that will **ONLY** be used for HF. The waste HF container should only be made of polyethylene or Teflon.
- POST a sign indicating the HF is being used in the work area (or laboratory). On the sign use "Hydrogen Fluoride" not "HF".

Laboratory Equipment Required:

- HF specific first aid kit which includes 2.5% calcium gluconate gel and/or 0.13 benzylalkonium chloride.
 - HF specific spill kit which includes absorbent, PPE, and containment bags
 - Fully functioning eyewash stations and safety showers – or combo eyewash/deluge systems
- *Note: calcium gluconate has a 6 month expiry date. Replace every 6 months.*

First Aid:

1. Skin Contact:
 - a. Ensure scene is safe.
 - b. Protect yourself from exposure with PPE (gloves, labcoat, and goggles).
 - c. Direct individual to safety shower, remove clothing, and flood affect area thoroughly with large amounts of water (can remove clothing while under shower).
 - d. Apply calcium gluconate to affected area (can be applied while being showered down).
 - e. Call 911 and inform of the HF exposure
 - f. Call ext 22222 (UW Police) and inform them that 911 has been called. Ask them to meet and direct the paramedics to the incident location
 - g. Call ext 33587 and notify the safety office
 - h. Apply calcium gluconate every 15 minutes and continue while transporting to the hospital

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- i. One first aider or co-worker should accompany the victim to the hospital
 - j. Provide responders with "MSDS"
2. Eye Contact:
- a. Ensure scene is safe.
 - b. Protect yourself from exposure with PPE (gloves, labcoat, and goggles).
 - c. Direct individual to eye wash and flush eyes with water for at least 15 minutes. Hold eyelids open and away from the eye during irrigation. If contact lenses are worn, they should be removed (if possible).
 - d. Do not apply calcium gluconate or benzylalkonium chloride to eyes
 - e. Call 911 and inform of the HF exposure
 - f. Call ext 22222 (UW Police) and inform them that 911 has been called. Ask them to meet and direct the paramedics to the incident location
 - g. Call ext 33587 and notify the safety office
 - h. Ice water compresses may be used while being transported to hospital
 - i. Provide responders with "MSDS"
3. Inhalation
- a. Ensure scene is safe.
 - b. Protect yourself from exposure with PPE (gloves, labcoat, and goggles).
 - c. Remove victim from exposure
 - d. If victim is not breathing, begin artificial respiration immediately. Mouth to mouth is not recommended, use CPR shields or preferably use an oxygen mask.
 - e. Call 911 and inform of the HF exposure
 - f. Call ext. 22222 (UW Police) and inform them that 911 has been called. Ask them to meet and direct the paramedics to the incident location
 - g. Call ext. 33587 and notify the safety office
 - h. Provide responders with "MSDS"
4. Ingestion:
- a. Ensure scene is safe.
 - b. Protect yourself from exposure with PPE (gloves, labcoat, and goggles).
 - c. Have the victim drink large amounts of water
 - d. Administer 100 mL of milk of magnesia or 30 tablets of Tums or another antacid with water
 - e. Call 911 and inform of the HF exposure
 - f. Call ext. 22222 and inform that 911 has been called. Ask them to meet and direct the paramedics to the incident location
 - g. Call ext. 33587 and notify the safety office
 - h. Provide responders with "MSDS"

Training

All individuals using HF should be given practical training in the use, handling, and response to HF related emergencies. If you are reading this and you have not received any such training **STOP** and contact your supervisor. At a minimum you should have the following training **PRIOR** to work with HF:

- Training on this document
- Training on the hazards and health effects of HF
- **PRACTICAL** training on any lab-specific SOP using HF
- How to administer first aid to yourself in case of an HF exposure
- How to handle a spill of HF
- Where first aid kits, spill kits, eyewashes, and safety showers are located
- Who to contact during an emergency and how to contact them

****Note if you have not be trained in the above, contact your supervisor and request it!***

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Emergency Procedures

Table 3: Summary of first aid and emergency procedures for exposure to HF.

Emergency Response Plan for Hydrofluoric Acid Exposure					
Inhalation	Skin	Eyes	Ingestion	PPE Only	Room
<ul style="list-style-type: none"> Ensure scene safety Protect yourself with PPE Leave area with HF vapors Call 911 Call 22222 to notify UW Police Call 33587 (Safety Office) Have a paper copy of MSDS ready for paramedics 	<ul style="list-style-type: none"> Ensure scene safety Protect yourself with PPE Remove contaminated clothing Wash area with water for 2-3 minutes Begin Applying 2.5 % Calcium Gluconate Gel with gloves on Call 911 Call 22222 to notify UW Police Call 33587 (Safety Office) Have a paper copy of MSDS ready for paramedics 	<ul style="list-style-type: none"> Ensure scene safety Protect yourself with PPE Flush continuously with water Call 911 Call 22222 to notify UW Police Call 33587 (Safety Office) Have a paper copy of MSDS ready for paramedics 	<ul style="list-style-type: none"> Ensure scene safety Protect yourself with PPE Get exposed individual to drink 1 glass of water Administer 100 ml of milk of magnesia or up to 30 Tums (or other antacid tablets) DO NOT induce vomiting Call 911 Call 22222 to notify UW Police Call 33587 (Safety Office) Have a paper copy of MSDS ready for paramedics 	<ul style="list-style-type: none"> Remove any visible liquid with red pH sensitive towels Remove / check / get new PPE as needed Dispose of old PPE in a thick plastic waste bag, label, and bring to ESF with a label on it. 	Small spill (< 500 mL)
					Large spill (> 500 mL)
					<ul style="list-style-type: none"> Protect yourself with PPE Pour Soda Ash or Uni-Safe Sorbent Call 35755 (Safety Office) for disposal instructions
					<ul style="list-style-type: none"> Leave the area Remotely call 22222 UW Police Call 33587 (Safety Office) and notify