

## **Breadth of Hazards**

### **Process:**

At NCNC, you will be working around a wide variety of concentrated hazardous chemicals. To keep safe, you must understand the potential hazards of all NCNC chemicals. You will not need to know how to effectively work with every chemical you may be exposed to, but you must be aware of their presence and their hazardous properties in order to work around them safely.

### **Materials:**

Liquid chemicals can be broadly summarized as acids, bases, fluorides, organics (aka. solvents/fuels) and oxidizers. You can anticipate which class (or classes) a chemical will be by its name:

Acids' names end in "Acid" .

Bases' names end in "Hydroxide".

Fluorides' names contain "Fluori-"; Names containing "Fluoro-" are not considered fluorides for this.

Organics' names end in "ane" "ene" "one" "ol" or "yde".

Oxidizers' names contain "Peroxide" or "Nitr-".

Common examples at NCNC include: Acetic Acid, Ammonium Fluoride, Ammonium Hydroxide, Hydrochloric Acid (HCl), Hydrofluoric Acid (HF), Hydrogen Peroxide, Nitric Acid, Potassium Hydroxide, Phosphoric Acid, and Sulphuric Acid. When combined, the above materials can form the following common mixtures: Aqua Regia, BOE, HNA, PAN, Piranha, RCA1, RCA2, and SulphoNitric.

Almost every chemical and mixture looks identical to water, so you will need to treat unknown chemicals with enough care that you won't get hurt regardless of the possibilities.<sup>1</sup>

### **Incompatible Materials:**

Avoid mixing unknowns and avoid mixing chemicals from different classes because some mixtures will create excessive heat, toxic gasses, or explosives. As written in the 'mixing' SOP<sup>3</sup>: Mixing compatible chemicals correctly creates little additional hazard. Mixing acids and bases creates excessive heat and can splatter chemicals from floor to ceiling. Mixing oxidizers and organics can form explosive solids or highly flammable liquids. Mixing oxidizers with acids or bases often powerfully amplifies the oxidizer's reactivity and creates toxic gasses and explosives. Mixing organics with acids or bases occasionally makes 'condensate' gunk. Although there are hazards to mixing chemicals of different classes, these sorts of mixtures are still commonly made at NCNC. Almost all of the mixtures listed in the Materials section above contain at least two classes of chemical.

\*Additional SOPs available, see: 1. PPE Choice and Cleaning  
5. Haz Waste Management

2. Work Station Use

3. Pouring and Mixing

4. Sharps

## **Hazards:**

You will need to learn the possible exposure routes, time frame and symptoms of NCNC hazards. Through the negligence of other lab members, you may be exposed to any of these at any time, so keep a watchful eye for trouble. Processes at NCNC regularly use chemicals in volumes sufficient to kill. Key words are bolded or italicized, and will appear throughout this SOP and others.

Chemical hazards at NCNC have three plausible routes: Inhalation, Contact and Explosion.

**Inhalation hazards** cause harm when breathed. Inhalation hazards primarily arise from materials that evaporate quickly (*high vapor pressure*), from the steam of boiling chemicals (*entraining*), and from plumes of mist (*aerosols*) created when mixing water into acids or bases. You will be able to smell any of NCNC's inhalation hazards before they reach hazardous levels, but some inhalation hazards can quickly anesthetize your nose so you can't smell (see Anesthetics below). No personal protective equipment (PPE) at NCNC will protect you from inhalation hazards, so if you notice an inhalation hazard your only available safety is to hold your breath and leave the area<sup>1</sup>. Working over plenums<sup>2</sup> will help prevent inhalation hazards from ever reaching you, like a fume hood would. Lastly, some NCNC equipment uses large amounts of toxic gasses from cylinders, but these gasses are difficult to expose yourself to. Gas sensors monitor most of these gasses, and a dedicated gas alarm will sound when they detect a leak.

**Contact hazards** cause harm when touched or splashed by. The most common forms of contact are caused either from chemical *residues*, from being careless around unknown chemicals, or from splattering/mist caused when pouring and mixing chemicals<sup>1</sup>. The hazardous residues left by chemicals can look like water, white crystals or even be invisible. Your mandatory white nitrile gloves will protect you from any invisible residues, but you can still burn yourself by touching a contaminated surface and then touching your face. In addition, to prevent spreading residues never touch common surfaces (doors, phones, etc.) while wearing heavy chemical gloves. Finally, some chemicals can soak through NCNC provided PPE, often without marking the PPE in the process (*PPE Penetrators*). The PPE SOP<sup>1</sup> discusses habits to mitigate this risk, and discusses the few PPE penetrator hazards that cannot be avoided.

**Explosions** are rare but still a risk. They are typically caused by one of these three routes<sup>5</sup>:

1. Tightly capping waste oxidizers\*\* bottled for disposal ('bottle pops')
2. Mixing organics into oxidizers\*\*, or using the wrong plastic tweezers (like Delrin or Celcon) in oxidizers.
3. Opening several year old bottles of '*peroxide former*' organics. Notify NCNC staff if you see such bottles.

\*\* The most common oxidizers at NCNC are Hydrogen Peroxide and Nitric Acid.

Chemical hazards at NCNC have three plausible time frames: Acute, Chronic and Sensitizer<sup>1,5</sup>.

**Acute Hazards** will hurt you immediately after exposure or up to a day later. Typically, they burn, but they can also poison. Acids, bases, oxidizers and fluorides all tend to exhibit acute hazards<sup>1</sup>.

**Chronic Hazards** will harm you eventually, sometimes years after exposure. Though even small amounts can be harmful, the effect isn't bad enough to be noticeable until years after exposed, or until many small exposures have accumulated. Chronic hazards in massive doses often become acute hazards. Organics most often present chronic hazards.

**Sensitizers** will harm you only after repeated exposures (often over many years), and are harmless in the meantime. NCNC's Nitrile gloves are sensitizers, as are many organics<sup>1</sup>.

Chemical hazards at NCNC have many ways they can harm you. The common mechanisms are: Anesthetic, Carcinogenic, Corrosive, Paralyzing, Skin Penetrators, Toxic, and Teratogens.

**Anesthetics** remove your ability to feel or smell a chemical as it burns you, making them extremely dangerous. If your nose ever tingles from inhaling a chemical you may lose your sense of smell and should leave the area. If you notice 'water' on yourself and there's any possibility it's a fluoride (an anesthetic), treat it as such<sup>1,2</sup>.

(Continued...)

**(Cont.)**

**Carcinogenic hazards** will greatly increase your likelihood of cancer. They tend to be chronic hazards and don't show symptoms until it's too late, making it very difficult to determine if you're being exposed. The best defense against carcinogenic materials is to consistently wear the right protective equipment<sup>1</sup> and to build careful working habits<sup>35</sup>.

**Corrosive hazards** (aka Caustic in some cases) will burn your skin upon contact, often terribly. Corrosives are all acute hazards, so symptoms appear within 24 hours and often begin with a painful tingle or rash.

**Paralyzing agents** make it very difficult to breath and in extreme cases can cause cardiac arrest. They tend to be acute.

**Skin Penetrators** will quickly absorb into your skin and through your body. They aren't necessarily hazardous on their own, but this property massively amplifies other hazards. Also, anything dissolved in a skin penetrator will be able to diffuse into your body much more readily.

**Toxic hazards** (aka poisons) will disrupt one of your internal organs, inducing sickness.

**Teratogens**, or developmental toxins, will only harm you if you're pregnant or nursing, but don't otherwise have ill effect in adults. NCNC commonly uses many extremely devastating teratogens, so if you're expecting or unsure, please ask for advice and ask a colleague or NCNC staff to perform your teratogen chemistries.

NCNC supplies many highly flammable liquids, often in squirt bottles.

**Flammables** will readily ignite by spark or flame. Because flammable organics are very common at NCNC the only way to avoid fires is to avoid creating sparks and flames. To that end, avoid bringing in electric equipment unless you can verify it's spark free. Fortunately, the high airflow at NCNC typically prevents flammable gasses from accumulating to explosive levels, especially over the plenums.

NCNC also presents a few non-chemical hazards: UV light, laser light, extreme temperatures, and sharps.

**UV Light** is generated by various machines at NCNC, and can damage your eyes. For NCNC's UV sources you would need to look directly at the source or work around it for a couple minutes to become noticeably injured. All NCNC UV sources also create a bright white, cool blue, or dim purple light while they are active. NCNC provides eye protection for working around these tools. Users will also post signs around hazardous UV sources when activated.

**Laser Light** is also produced by various machines at NCNC, and can damage your eyes. Most lasers at NCNC are low power and visible, which limits the likelihood of hazardous exposure.

**Extreme Temperatures** are present on samples coming out of furnace and anneal systems, and can be as high as 1000C. These temperatures will readily ignite tekwipes and solvents, and can burn you through metal tweezers. When working with these tools, you should wear thermal gloves provided by NCNC and avoid flammable organics. Hotplates and ovens can also become quite hot (400C) and should be treated with similar care when used at these temperatures. Extreme cold (*cryogenic*) temperatures are present at NCNC in certain pumps and tanks, but are nearly impossible to expose yourself to.

**Sharps** commonly include broken glassware, razor blades and syringes. Because these are so common at NCNC, sharps are a common source of minor injury. For more information see the Sharps SOP<sup>4</sup>.

**Chemical Exposure Actions:** Do what's below, and then notify NCNC staff within a few hours. For advice, call NCNC Staff.

**Eyes:** Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.

**Skin (non-Fluoride Chemicals):** Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

**Skin (Fluorides):** Remove splashed clothing, wash for 3 minutes, apply Calcium Gluconate gel and call 911.

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### **Personal Protective Equipment<sup>1</sup>:**

If approaching an unknown chemical, you need to wear protective equipment for any possibility. Wear goggles, a face shield, heavy chemical gloves (black Butyl/Viton)<sup>1</sup>, and a heavy chemical apron. The outer layer of the black gloves will break down in some materials at NCNC, but the inner layer will protect you from any of these. Keep an attentive nose out for inhalation hazards, because no personal protective equipment at NCNC will protect you from these.

### **Additional Process Notes:**

Following is a selection of 8 common chemicals at NCNC, and the hazards they present. These were chosen from hundreds of chemicals at NCNC to represent what you might come across in a typical day- they are not the most hazardous materials you might come across. For more information, most of the following chemicals (and many others) have dedicated SOPs already available at NCNC. Also, never forget that the NCNC staff is happy to work with you for learning chemical awareness.

Sulphuric Acid ( $H_2SO_4$ ) is an acid, an acute contact corrosive, and leaves persistent wet residues. In addition, it is a PPE penetrator when undiluted.

Hydrochloric Acid (HCl) is an acid, an acute contact corrosive, and an acute inhalation hazard.

Potassium Hydroxide (KOH) is a base, an acute contact corrosive, and leaves persistent crystalline residues.

Hydrofluoric Acid (HF) is an acid and a fluoride. It's a devastating acute contact toxin, an acute contact corrosive, a chronic contact toxin and an acute inhalation hazard. It's also a skin penetrator and an anesthetic. For its breadth of hazards and anesthetic properties, HF is one of the most dangerous chemicals at NCNC.

Tetramethylammonium Hydroxide (TMAH) is a base, a chronic carcinogen, and an acute paralyzing agent. At NCNC's concentrations, it's a mild contact corrosive.

Acetone is an organic, a skin penetrator, and a very mild chronic inhalation toxin. It is exceptionally acutely hazardous when it contacts the eyes, and exceptionally explosive when mixed with oxidizers<sup>3</sup>.

Dimethyl Sulphoxide (DMSO) is an organic, an exceptional skin penetrator, and a very mild chronic contact toxin. It is unfortunately a devastating teratogen.

Nitric Acid ( $HNO_3$ )<sup>3</sup> is an acid and an oxidizer. It's an acute contact corrosive, an inhalation hazard and can explode when mixed with organics or when improperly stored for disposal.

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