1 Introduction

This document contains information about handling and treatment of chemicals in the MiNaLab cleanroom. The intention is to provide a safe and efficient environment for all users. The purpose of the document is to keep users informed about safety policies and laboratory procedures. Everyone using the facilities should have knowledge regarding handling of chemicals as well as the equipment for processing of chemicals.

Any chemical or chemical reaction that goes out of control can create a serious incident with the risk of injury to people and damage to property and the environment by fire, explosion, burns or poisoning. This document provides guidance about how to ensure a safe chemical process along with appropriate emergency response. A section provides procedures concerning treatment of chemicals and operation of chemical equipment. The section also provides a brief description of some chemicals with serious hazards. Another section states procedures regarding decontamination and securing of the contaminated areas. Treatment and disposal of chemical waste is also one of the subjects of discussion.

2 Document history

Revision	Date	Prepared	Approved	Description
A	16-07-2010	Mikael Sjödin		Initial revision
B	19-02-2017	Halvor Dolva Kristin Bergum	Viktor Bobal	Several sections have been updated

Contents

3 Definitions

Chemical waste
A chemical that falls into one of the following categories:

- Any chemical that has passed its expiration date.
- Mixture of chemicals which cannot be reused.
- Chemical products due to decontamination or cleaning up chemical spills.

Contamination
Chemical contamination is defined as spill of chemicals out of a place where one has full control over them. In this case the spilled chemicals can damage the people, equipment, and environment. The process that one goes through in order to clean up the spill (contaminant) is called decontamination.

Corrosive chemical
A corrosive chemical is one that:

- Causes visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact
- Has a pH greater than 12 or less than 2
- Is known or found to be corrosive to living tissue

The major classes of corrosive chemicals are strong acids and bases, dehydrating agents, and oxidizing agents. Some chemicals, e.g., sulphuric acid, belong to more than one class. Inhalation of vapours and mists of these substances can cause severe bronchial irritation. These chemicals erode the skin and the respiratory epithelium and are particularly damaging.

Dehydrating agents
Extreme heat is evolved when these substances are mixed with water, mixing should always be done by adding the agent to the water to avoid a violent reaction and spattering. Because of their affinity for water, these substances cause severe burns on contact with skin. The strong dehydrating agents include concentrated sulphuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide.

Emergency
An occurrence such as equipment failure, rupture of containers, or failure of control equipment that results in uncontrolled release of a hazardous chemical into the workplace.

Explosive chemical
Chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

First aid measures
Procedures regarding immediate care given to a person who is injured or who suddenly become ill. It can range from cleaning a cut and applying a bandage to helping someone who is choking or having a heart attack.

Flammable
A chemical that falls into one of the following categories based on US Code of Federal Regulations:

- Flammable aerosol - An aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening.
- Flammable gas - A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air higher than than 12 percent by volume, regardless of the lower limit.
- Flammable liquid - Any liquid having a flashpoint below 100°F (37.8°C), except any mixture having components with flashpoints of 100°F (37.8°C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.
- Flammable solid - A solid, other than a blasting agent or explosive, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard.

A chemical shall be considered to be a flammable solid if, when tested by the method 3 described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Fume hood
A device, located in a laboratory, enclosed on five sides with a moveable sash or fixed partial enclosure on the remaining side, constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory, which allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Hazardous chemical
A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins and agents which act on the hematopoietic systems and agents which damage the lungs, skin, eyes, or mucous membranes.

Incompatible chemicals
Incompatible chemicals give an undesired chemical reaction when mixed. This usually refers to substances that will react to cause an imminent threat to health and safety through an explosion, fire, and/or formation of toxic materials.

Material Safety Data Sheets (MSDSs)
Information on chemical products supplied by product manufacturers or distributors which includes information on the physical hazards, health hazards, safe handling procedures, and emergency and first aid procedures.

Neutralization
Any chemical reaction, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste non-hazardous, or less hazardous; safer to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

Protective laboratory practices and equipment
Those laboratory procedures, practices, and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective in minimizing the potential for employee exposure to hazardous chemicals.

Resin ware
Containers made of synthetic polymeric compounds physically resembling natural resin, e.g. polyvinyl, polystyrene, or polypropylene etc.

Toxic chemicals
Any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions or elsewhere.

Wet bench
Typically fully automatic process tool used to carry out wet cleaning and etching operations in semiconductor processing; commonly includes several tanks each containing either cleaning/etching solution or deionized rinsing water in which wafers are immersed in predetermined sequence; typically includes also drying module.

4 Treatment of chemicals

4.1 Treatment of chemicals

This section provides procedures concerning treatment of chemicals and work with different chemical equipment. The section provides also a brief description of some chemical with serious hazards.

4.2 Assignment of responsibilities

Those who supervise and economically support your project study in the cleanroom (i.e. supervisor, head of department) are the ones who are responsible for the nature of your study work.

Cleanroom staffs are those who are responsible to provide the chemical and equipment that you are in need. They also provide all necessary guidance on how you can ensure a safe chemical process.

Cleanroom staff:

- Viktor Bobal – Room responsible
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If an incident or accident occurs, despite efforts of preventive nature, this must be reported to laboratory staff for investigations into possible modifications of tools, procedures or rules, in order to prevent that the incident is repeated in the future. All users are encouraged to inform the lab staff whenever any potential dangerous behaviour or situation is observed, in order to also prevent possible accidents.

4.3 Protective laboratory practices and equipment

4.3.1 Preventive personal protection

To ensure a safely laboratory study one should go through the following lab procedure prior to processing any chemical.

1. Go through the procedures regarding your laboratory work step by step. Ask your supervisor and/or the cleanroom staff if there is any doubt about applicability of the procedures.
2. Check if the chemical and equipment that you need are available in the cleanroom. Contact the cleanroom staff if this is not the case.
3. Check if the equipment is in good working order.
4. Read the Material Safety Data Sheet (MSDS) prior to using a chemical or material.
5. Check if the personal protective clothing and equipment that you need is available in the cleanroom.

4.3.2 Personal protective clothing and equipment

4.3.2.1 Body protection

The coveralls used in the cleanroom laboratory are made of material that resists splash of chemicals, but not solvents. Chemicals may get thru and can harm your clothes and skin.

During handling of chemicals a **chemically resistant apron** shall be used**.** The aprons are located next to the wet benches.

4.3.2.2 Eye and face protection

When working with chemicals safety googles shall be worn. Face shields shall be worn when there is danger of splashing chemicals or flying particles, such as when chemicals are processed at wet benches and fume hoods or glassware is used under elevated or reduced pressure or elevated temperature. Face shields must be cleaned after use. **Do not** use **acetone** for cleaning. TexPure or ethanol is adequate for cleaning.

The wall mount eye/face washes are not connected to any drain and water will be poured on the floor. Do not think of the floor being wet while using the washes.

4.3.2.3 Hand protection

Gloves are worn to prevent contamination of your hands due to exposure to corrosive and toxic chemicals as well as infectious agents. Another purpose of using gloves in the cleanroom is to prevent particles and dirt spreading from our hands to clean surfaces or the environment.

To prevent contamination of your hands or work surfaces, wash gloves thoroughly with water before removing them. Pull off disposable gloves inside out and dispose

them according to the nature of the contaminant. Always remove contaminated gloves before leaving the laboratory.

Always wash your hands after removing gloves, **before** leaving the work area, and before eating, drinking, smoking, or applying cosmetics.

Use the right gloves for the job. Many gloves are made for specific uses. For adequate protection, select the correct glove for the hazard in question. In the MiNaLab's cleanroom one can find three different types of gloves.

Nitrile gloves: These are the blue gloves normally used when entering the cleanroom. Nitrile gloves are not strong chemical resistance gloves and should be used together with **Trionic** gloves for treatment of chemicals. It is OK to use nitrile gloves for iso-propanol and ethanol, but note that iso-propanol will penetrate the gloves after 20 minutes and ethanol after 30 minutes.

Latex-gloves: Latex gloves can be used when one is running a process other than chemical process. The purpose of using these gloves is to keep the instruments and other contact surfaces clean. Latex gloves do not provide protection from chemicals.

Trionic gloves: Trionic gloves provide protection from wide range of aggressive etchants, acids, and bases. Ideal for wet chemical applications

Important notes:

- If the gloves are contaminated with Hydrofluoric Acid, cyanide, or any other toxic chemical they must be consider as chemical waste and must be disposed of. If **gloves** and/or **wipers** are contaminated with Hydrofluoric Acid they shall be flushed thoroughly with water in the wet-bench sink and disposed in the Acid Waste box.
- The cleanroom **users** are responsible to **wash** the **glove** and **clean** the **face shields** before leaving them in their respective places
- Do **not** leave the **gloves and face shield on** the **tables**, not even temporarily. They contaminate the tables which in turn hazards the other users and cleanroom Cleaning Crew.
- Avoid touching anything outside the wet bench during handling of chemicals and especially HF

4.4 General guidelines for chemical processing

This section provides a quick checklist to assist you conduct your laboratory studies safely and in compliance environmental health and safety regulations. The guidelines consist of three different checklists that one should go through them at three different occasions.

4.4.1 Before starting to run the chemical process

1) Apply for access to the cleanroom.
2) Attend the courses
   a) The cleanroom course
   b) Wet bench license course

3) Go through all references regarding your studies and take notes on;
   a) All chemicals, instruments, glassware, resin ware (see Appendix A), personal protective clothing, equipment and materials that you will need.
   b) Safety percussions and extra warning notices.
   c) Decontamination equipment that will be needed (see Appendix B and Appendix C)
4) Contact the cleanroom staff and check that the articles mentioned above are available.
5) Mark your chemical with your name, name, and date.
6) Read the *Material Safety Data Sheets* (MSDS) of all chemicals that you will be using and check if those are available in their respective places in the MSDS-files in the cleanroom.
7) Find the instruction regarding disposal of your chemical as waste and instruction for neutralizing your chemical as spill (see Appendix C) or contact the cleanroom staff.
8) Write down the procedure for your project studies in details.
9) Make a list of chemical or chemical groups that are incompatible with your chemicals.
10) In case HF and/or Cyanide are allowed to be treated in the laboratory location where you run your studies do as follows;
   a) Read the instruction regarding “first aid measures” for these chemicals
   b) Check if the proper HF-antidote gel is available in the cleanroom. Note that it shall not be more than two years old.
11) Check;
   a) That all Equipment, benches, and fume hoods that you will be in need are working properly.
   b) That the ventilation system is working.
   c) That there is sufficient space to measure and process your chemicals.
12) Finally check the location of the following emergency items:
   a) Equipment emergency shutdown button
   b) Emergency alarm button.
   c) Emergency telephones and Emergency telephone numbers
   d) Fire extinguisher
   e) Emergency doors
   f) Eye Washers

Note: Before and after every treatment one should check that the gloves are without holes. Gloves with a hole shall never be used. Wash these gloves and dispose them in the acid waste bin. If gloves with holes are contaminated with a toxic chemical they should be left in a waste-box underneath a ventilated hood. Please notify staff.

4.4.2 After running a process

Leave all instruments and equipment back to their proper place after use.

1) Note that beakers and bowls must be washed by DI water and placed directly in their respective place or shelf.

2) Balances, Magnet stirrer, hotplates (heating plates) must be cleaned (with Text-pure solution) before leaving them to their respective place.
3) Wash and clean the equipment after use.
4) Wet benches, spin benches, fume hoods must be cleaned after use
5) Baths should be emptied, in case it is requested, and washed.
6) Treatment and handling of chemical waste and contaminated laboratory ware:
   a) Bottles containing chemical waste should have the chemical waste-label on. Information on content of the bottles should be written on these labels. These bottles should be placed in proper chemical cabinet.
   b) If the wipers, gloves or other disposal laboratory ware are contaminated with HF they should be deposed off as follows:
      i) Flush them thoroughly with water in the wet-bench sink.
      ii) Dispose them in the Acid Waste- box.
   c) If the wipers, gloves or other disposal laboratory ware are contaminated with toxic chemicals they should be deposed off as follows:
      i) Fill the bag with contaminated objects
      ii) Write name of toxic chemical on the bag or use the label for chemical waste, store underneath a ventilated hood and notify staff.
   d) Wash the gloves and clean the face shields before you leave them in their places. Note that the face shields should not be cleaned by **acetone**.

4.4.3 After completion

1) Collect all your belongings from clean room, or put it in your storage box and leave it to its respective place.
2) Leave the tweezers, timer in your “storage box”, and chemicals in the chemical cabinet.
3) In case the chemicals that you have used in your studies will not be used by others they should be transported to the storage-room. Contact the cleanroom staff for assistance.
4) Check if you have left any unlabelled chemical waste.

4.5 Providing chemicals

The cleanroom staff is in charge of ordering and placing the chemicals that are regularly used in MiNaLab. Material Safety Data Sheet (MSDS) of all chemicals are filed and available in LIMS and a short form is available as a paper copy in the cleanroom. Those who will use their own chemical should hand over the chemicals and their respective MSDS to the chemists for initial inspection and for storage if that is applicable.

You should contact the chemists in case you need to order chemicals for special studies.

4.6 Treatment of chemicals

Measuring, weighing, and mixing of chemical should be done in the proper fume hood or wet bench and one should wear proper protective gear during the treatment.

Use both of your hands to hold the container of chemicals while transporting them. Use a chemical transport cart for transport if you have more than one container.

Empty bottles of chemicals should be placed in their respective place in the “Empty Bottle” container in the decontamination room. Note that that the bottles **should be flushed at least 3 times with water** and emptied properly and the caps shall be disposed in the regular waste bins.

4.7 Storage of chemicals

Chemicals have to be stored in cabinets that are connected to ventilation system. Only those chemicals that are compatible with each other are allowed to be stored in the same cabinet.

Two different types of cabinets are assigned for storage of chemicals:
1) Acid cabinets (liquid state): Chemicals that are inorganic acids, base, oxidizing or water based chemicals, as well as nontoxic inorganic salts should be stored in such cabinets.
2) Solvent and base cabinet.

Dress with proper protective wear before you start to transport the chemical for further treatment. Only the empty bottles of photoresist have to be rinsed by **acetone** before being placed in their respective places.

If you want to store a mixture of different chemicals contact the cleanroom staff for further assistance.

4.8 General safety guidelines for fume hoods and wet benches

Before working with the hoods and/or benches check the followings:
1) Choose the right hood and /or bench depending to the nature of the chemical that you want to treat (i.e. acid hood/bench or solvent hood/bench).
2) The ventilation face velocity of the Hood should be between 0.4-0.8 m/sec and the minimum velocity at the middle of the bench should be about 0.5 m/sec.
3) Check if the necessary personal protections are available in the laboratory location.

4.8.1 Fume hoods

1) The hood sash must be marked at maximum use opening (vertical sliding sash only). Do not use the hood with the sash above this mark.
2) Do not place your face inside the hood. Keep hands out as much as possible.
3) Keep sources of emission 15 centimetres inside the hood.
4) The hood should not be used for chemical storage except for strongly malodorous compounds.
5) Chemicals stored in the hood must be in a capped or covered container. The content chemical must be identified by name, concentration, and hazard symbol.
6) Avoid storing large amounts of chemicals in the hood, it obstructs airflow and reduces usable space.

7) Avoid cross drafts and disruptive air currents in front of the fume hood. Do not slam the doors in the room while people are working at the hood.
8) Avoid blocking off baffle exhaust slots in any manner. Elevate large equipment 5 centimetres off the base of the fume hood.

Use of coat apron in neoprene is compulsory while treating chemicals in a fume hood.

4.8.2 Wet benches

Those who want to work with wet benches have to attend the “Wet bench course”. The following applies when working at wet benches:

1) Wear proper personal protective gear
2) Do not mix chemicals in the baths
3) Do not place your face directly above the bath

4.8.3 Resist spinner bench

These benches are used to spin photoresist layer on a chips or wafer. Photoresist and acetone are the only chemicals treated at such benches. Both of these chemicals are flammable. Photoresist are of various types and contains polymer and solvent.

1) All wipers and syringes contaminated with photoresist should be disposed in the waste basket which is connected to ventilation system.
2) While filling the syringes with photoresist write the name of photoresist and the date on the syringes.

4.8.4 General guidelines for processing of chemicals at Hoods and Wet Benches

Clean up the spills after any process.

- Use the cleanroom wipers
- Leave the contaminated wipers in the acid or solvent wiper-box
- For major spills, see section 5 on decontamination

4.9 Glassware and resin ware

To ensure an uncontaminated process in the cleanroom glassware and resin ware are classified in to 3 different classes or labelled for a specific chemical.

- Class I: Not to be washed in dish washing machine. Used for treatment of water, RCA1, RCA3, and dilute solutions.
- Class II: Used for treating pure acids, solvents, and water soluble salts.
- Class III: Used for treatment of water insoluble organic solvents

1) Use labelled glassware to treat photoresist in. Wash the container with acetone after treatment.

2) It is absolutely forbidden to leave the glassware, containing chemical, in any place other than in the fume hood. If you need to leave chemicals underneath a fume hood, always label it with the following:
   a) Your name
   b) Your telephone number
   c) Chemical, concentration, and hazard symbol
   d) Time of removal
3) After any process the glassware and resin ware used in the process must be rinsed and the marks on them should be removed by acetone and they should be placed in their respective box/place.
4) Use the right resin ware for right process (see Appendix A)

Note: Never use glassware with HF containing solutions; see Appendix A for selection of proper resin

All process laboratory users are responsible to learn the rules regarding handling of glassware

Use of wrong glassware contaminates the container which in turn damages the others process studies.

4.10 Acid and solvent drains

It is not allowed to pour any types of chemicals in the wet bench drains. Only residues of chemicals left in beakers and empty bottles flushed in the drains. Small spills of chemicals comes on the bench are also allowed.

Contact the cleanroom staff in case you are not sure if your chemical waste is allowed to be spill out in the drains or not.

4.11 Chemical emergency and first aid measures

The purpose of this section is to go through those procedures which guide us how to rescue a victim who is exposed to hazardous chemical and how to prevent further improvement of the contamination.

1) Rescue the victim, following the instruction given in section 4 respective MSDS.
2) Shutdown the equipment that victim was working with (push the emergency shutdown bottom)
3) Call emergency if necessary, Ambulance, Rescue Centre, and Toxin-Information (see Appendix E).
4) Inform the cleanroom staff.
5) Inform the others to evacuate the contaminated area.
6) Decontaminate the area if possible.
7) Report the accident to the cleanroom Safetyman.

4.11.1 Eye and face wash

Two types of general eye/face wash are available in the cleanroom. The first type is the wall mount eye/face washes, which are available in all laboratory locations where

treatment of chemicals are allowed. The other type is portable eye wash bottle. These bottles are used while moving the victim to the eye clinic.

For HF cases a special eye wash bottle is available at the acid bench.

4.12 Hazardous chemicals

"What is it that is not poison? All things are poison, and nothing is without poison. It is the does only that makes a thing not a poison."

Paracelsus (1493-1541)

All chemicals are considered to be hazardous materials specially those which are treated in a wrong way. In following sections we will be discussing the chemicals that should be treated or handled with special care.

4.12.1 Hydrofluoric acid (HF)

Hydrofluoric acid is both corrosive and toxic. Toxic effect appears with;

1) Inhalation
2) Skin contact
3) Swallowing

Severe burns occur after exposure of concentrated (i.e. 50% or stronger solution) HF acid to 1% or more Body Surface Area (BSA), exposure to HF acid of any concentration to 5% or more BSA, or inhalation of HF acid fumes from a 60% or stronger solution. The vast majority of cases involve only small areas of exposure. Safe shoes that´s resistant to acid is to prefer.

Local effects include tissue destruction and necrosis. Burns may involve underlying bones. Systematic fluoride poisoning from severe burns is associated with sudden death. Deaths have been reported from concentrated acid burns to as little as 2.5%BSA

Time of exposure to onset of symptoms is related to the concentration of the HF acid.

> 50% concentration immediately produces symptoms with deep and painful tissue damages.

20- 50% concentration immediately produces symptoms. Sign of deep tissue damages are shown after several hours.

12% concentration produces symptoms after 1 hour. Sign of deep tissue damages are shown after 24 hours.

< 7% concentration produces symptoms after several hours

HF Warning notices are attached to the Wet benches where treatment of Hydrofluoric acid is allowed. At the Wet benches can you find HF-antidote gels used to apply onto skin that has been exposed to HF.

Before treating HF check if HF-antidote gel is available in the room and the gel is not more than 2 years old. Note that the gel has to be unused and must be disposed of after use.

4.12.2 Potassium hydroxide, KOH

This chemical causes blindness immediately after contact with eyes.

1) While cooling the KOH baths, especially the baths with inline heater, keep the pump on operation.
2) Wear always face shield even if you want to control the KOH level in the bath.
3) Follow the instruction for EYES IN CONTACT WITH HARMFUL LIQUIDS given in Appendix D as first aid measure for Potassium Hydroxide.

4.12.3 Piranha (7-Up), H2SO4+H2O2 (1:1)

Piranha solution is very energetic and potentially explosive.

There are two different suggested procedures for preparing 7up solution;

1) Add H2O2 to H2SO4, acting slowly (recommended)
2) Add H2SO4 to H2O2, acting slowly

One can follow any of these two procedures, but in both cases one must act slowly while mixing the chemicals. Mix the solution in an acid fume hood and wear the protection (***Trionic or Latex gloves, face shield and apron***). If the concentration of H2O2 is at 50% or greater, an explosion could occur.

Mixing hot Piranha (7-Up) solution with organic compounds may cause an explosion. This includes acetone, photoresist, Isopropyl alcohol, and nylon.

Hot Piranha (7-Up) explodes in air tight container. Solution must be cooled in an **open** container and stores as waste in a closed container. The container should be labelled (per instruction for chemical waste).

4.12.4 BOE, buffered oxide etch

Due to the high health risk nature of the acid involved in this process, users are advised to heed the Material Safety Data Sheet carefully before carrying out the process. BOE consists of HF, see section 4.12.1.

Trionic acid resistant gloves must be worn over latex gloves during the whole process.

Used BOE solution must *not* be dumped into the sink. Discard used BOE solution in the container labelled “Waste BOE” located in the cabinet for acids. Clean any acid spill immediately to avoid endangering other users.

4.12.5 Caesium, Cs

Isolated caesium is extremely reactive and very pyrophoric. In addition to igniting spontaneously in air, it reacts explosively with water. The reaction with solid water occurs even at temperatures as low as −116 °C. Because of its high reactivity, the

metal is classified as a hazardous material. It is stored and shipped in dry mineral oil or in other dry saturated hydrocarbons or in an inert atmosphere (such as argon or nitrogen) or vacuum in sealed borosilicate glass ampoules.

Handling caesium in the lab must always be done under ambient argon.

4.12.6 Cadmium, Cd

The Cadmium compound which is treated in the cleanroom is a Cadmium Compound as a by-product of the MOCVD process. Treatment takes place in special prepared areas with authorized people.

The contaminated wipers and gloves are disposed in a container marked Cd-waste. Cadmium compound waste is kept in the assigned place in the decontamination room for further transport. The bag is removed by only authorized people.

Symptoms: Long exposure to Cadmium causes cancer. This is the potential for harm to the kidneys and lungs.

Effect of Short exposure can include:
- Sore eyes, nose and throat;
- Coughing, headache, dizziness, and weakness;
- Chill, fever, chest pain and breathlessness.

If swallowed the following symptoms may occur:
- Nausea, vomiting, diarrhoea, muscular cramps and salivation.
- Weakness
- Headache
- Giddiness
- Confusion

Those who treat Cadmium and its compounds have to be well informed on precaution regarding treatment of these chemicals. Following are list of some useful articles on Cadmium.

a. INDG391 - **Cadmium** and you - working with **Cadmium** - are you at risk ?

http://www.hse.gov.uk/pubns/indg391.pdf

b. CADMIUM https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=15

4.12.7 Oxidizing agents

Oxidizers, because of their chemical structures, have excess oxygen which may be liberated, especially at higher temperatures.

The primary hazard associated with this class of compounds lies in their ability to act as an oxygen source, and thus to readily stimulate the combustion of organic materials.

Do not forget to wash your hands when you leave the cleanroom no matter if you have handled or treated any chemical. Think that you have touched an unassigned contaminated equipment or area.

Classification system for oxidizing materials

Oxidizers may be grouped into 4 classes based on their ability to affect the burning rate of combustible materials or undergo self-sustained decomposition. This classification system was established by the National Fire Protection Association (NFPA 43A, 1980) as a means to provide information on safe storage of oxidizing materials.

Class rating hazard description

Class 1
The primary hazard is that it may increase the burning rate of combustible material with which it comes in contact.

Class 2
The material will moderately increase the burning rate or it may cause spontaneous ignition of combustible material with which it comes in contact.

Class 3
An oxidizing material that will cause a severe increase in the burning rate of combustible material with which it comes in contact or which will undergo vigorous self-sustained decomposition when catalysed or exposed to heat.

Class 4
This oxidizing material can undergo an **explosive reaction** when catalysed or exposed to heat, shock or friction.

4.12.8 Cryogens LN2 (liquid nitrogen)

Liquid nitrogen (LN_2), Liquid Argon, Liquid Helium and Solid CO_2 (dry ice) are examples of cryogens. Cryogenic chemicals present a safety hazard due to their extreme cold. Users should be familiar with this hazard and use appropriate cryogen gloves as well as designated personal protective equipment against the freezing effects. Under no circumstances should a user allow to contact LN_2 with their body. Severe injury can result from such contact. **Note that eye protection is very important.**

All cryogens listed above can displace the oxygen in the air as they evaporate. Therefore you must only use nitrogen, liquid nitrogen, helium, liquid helium and carbon dioxide in well-ventilated rooms and after having performed an analysis of the amount of air that could be displaced by the cryogen proposed for use. Provided only a small fraction of the air will be displaced, the cryogen can be used safely. Keep the room especially well ventilated during use.

5 Decontamination

Chemical contamination is defined as spill of chemicals out of a place where one has full control over them. In this case the spilled chemicals can damage the people,

equipment, and environment. The process that one goes through in order to clean up the spill (contaminant) is called decontamination.

To decontaminate the spill one has to use special equipment.

When ordering new a chemical, check if the decontamination equipment present is sufficient (see Appendix B and Appendix C) to clean up this chemical in case the chemical acts as contaminant.

All cleanroom users are responsible to clean up small amount of spill, read sections 4.4.2 and 4.8.4.

Cleanroom staff should clean up large amount of spill or unknown spills. In case you notice large amounts of contamination do as follows:

a. Inform the people to evacuate the contaminated area

b. Inform the cleanroom staff

c. Do not leave the contaminated place until the cleanroom staff reaches the location or that is otherwise safety to do so

Some contaminants, especially those chemical with high concentrations must, for more safety, be **neutralized** prior to being cleaned up (see Appendix B).

6 CHEMICAL WASTE AND SHARP WASTE

Liquid chemical wastes are not allowed to be poured in the chemical drains and solid chemical waste should be removed to the waste container in the right storage cabinet. Pour the waste in the labelled containers in the chemical cabinets. The waste is later delivered to the community's chemical waste stations.

Chemical waste containers shall always be labelled with the complete chemical name.

Pour the used chemical in the right waste container, who is located in the chemical store cabinets. This is 2 examples for waste chemical containers:

Appendix A8 shows a list of incompatible chemical. Label the waste containers with “UiO” to distinguish UiO waste from Sintef waste.

6.1 Treatment of the chemical waste

The last step of an experiment should include treatment of the chemical waste to reduce the hazards or toxicity of by-products. **All cleanroom users are responsible to collect, identify, and remove their chemical waste to the assigned places**. Follow the procedure given in Appendix G.

6.2 Handling of sharp waste

All broken glassware and wafers should be **decontaminated** before being disposed. Contact the cleanroom staff if the waste is contaminated or it is a **metal waste**. Dispose the wafers in the can labelled “USED WAFERS”, and glass/quartz in the bin labelled “GLASS”.

Appendix A Resin properties

The properties listed in this appendix are general properties. Different grades of the same resin can have considerable variation in the physical properties. This appendix is included as a guideline to help choosing the right resin for the job.

FLUORCARBON RESINS

PTFE (polytetrafluoroethylene) is a fully fluorinated opaque, white polymer with the lowest coefficient of friction of any solid. A common brand is Teflon PTFE from DuPont. PTFE has high impact strength, is subject to creep and is resistant to virtually all chemicals and solvents.

PFA (perfluoroalkoxy) is a fluorinated translucent, slightly flexible polymer with low coefficient of friction and outstanding anti-stick properties. A common known brand is Teflon PFA from DuPont. PFA has excellent stress crack resistance and because of its exceptional purity, does not pose an outgassing problem. PFA is resistant to virtually all chemicals and solvents.

ETFE (ethylene tetrafluoroethylene) is a white translucent resin that has higher strength than fully fluorinated polymers. A commonly known brand is Tefzel ETFE from DuPont. Glass reinforced grades have outstanding creep resistance. However, ETFE has somewhat lower chemical resistance than PFA and PTFE. Strong oxidizing acids, organic bases and sulphuric acid at high concentration, near their boiling points, will affect ETFE to various degree.

ECTFE (ethylene chlorotrifluoroethylene) has a higher strength than fully fluorinated polymers. A commonly known brand is Halar ECTFE from Ausimont, Inc. ECTFE has better creep resistance than PTFE and PFA. ECTFE has excellent abrasion resistance and impact strength even at cryogenic temperatures. ECTFE is resistant to a wide variety of corrosive chemicals and organic solvents, but is not resistant to hot amins.

PVDF (polyvenyliden fluoride) is an opaque, white resin with high strength and abrasion resistance, similar to ECTFE. Commonly known brands are Kynar PVDF from Atochem and Solef PVDF from Solvay. PVDF is resistant to most bases, salts, strong acids, oxidizing agents and organic solvents. PVDF has poor resistance to organic bases and certain organic solvents at room temperature.

NONFLUORCARBON RESINS

PP /polypropylene) is a translucent or transparent polymer that is highly flexible. PP is durable with good impact strength. PP has good resistance to strong mineral acids and bases, alcohols and some solvents. PP has poor resistance to chlorinated and aromatic solvents, concentrated hydrochloric acids and hydrogen peroxide at elevated temperatures.

PE (polyethylene) is available in various degrees of crystallinity, including LDPE (low density polyethylene) and HDPE (high density polyethylene). These materials have chemical resistance similar to polypropylene. Strong oxidizing agents will eventually cause embrittlement. Some solvents will cause softening and swelling of the resin.

PMMA (polymethyl metacrylate) is a clear, rigid polymer with good impact strength. The clarity of PMMA is equal to glass and is used with transparent colours to control UV light transmittance. PMMA has excellent dimensional stability. PMMA has good resistance to bases, oils, most mineral acids, salt solutions and detergents, but is attacked by most solvents.

PS (polystyrene) is a transparent, rigid, brittle polymer with excellent dimensional stability. PS is subject to stress cracking and some of the higher impact grades incorporate butadiene for added impact strength. PS is resistant to water, weak acids and bases and detergents, but is attacked by most organic solvents.

ABS (acrylonitrile butadiene styrene) is a rigid, tough polymer with good impact strength. ABS is available in transparent and coloured grades. ABS is resistant to most acids, bases, salt solutions and many alcohols, but is attacked by most organic solvents.

PC (polycarbonate) is a rigid, transparent polymer with high impact strength, and is also available with transparent colours to control UV transmittance. PC has good dimensional stability and is generally compatible with weak acids, bases, oils and alcohols at room temperature. PC is attacked by organic solvents and concentrated acids and bases at elevated temperatures.

PSO (polysulfone) is a strong, colourable, yellowish clear polymer. PSO is highly resistant to aqueous mineral acids, bases and salt solutions and has good resistance to detergents, oils and alcohols even at elevated temperatures and stresses. PSO is not compatible with most organic solvents, especially alcohol.

PES (polyetherfulfone) has excellent heat resistance, dimensional stability and creep resistance. PES has good resistance to most inorganic chemicals, aliphatic hydrocarbons and most solvents including chlorinated and fluorinated reagents. PES is attacked by esters, ketones, methylene chlorides and polat aromatic.

PVC (polyvinyl chloride) is similar in structure to polyethylene, but each unit contains a chlorine atom. The chlorine atom renders it vulnerable to some solvents, but also makes it more resistant in many applications. PVC has extremely good resistance to oils (except essential oils) and very low permeability to most gases. PVC is transparent and has a slight bluish tint. Narrow-mouth bottles made of this material are relatively thin-walled and can be flexed slightly. When blended with phthalate ester plasticisers, PVC becomes soft and pliable, providing useful tubing to be found in every well-equipped laboratory.

PEI (polyetherimide) is a clear amber polymer. A commonly known brand is Ultem PEI from G. E. Plastics. PEI can be coloured with opaque colorants. It has excellent long-term resistance to creep at high temperature and stress. PEI is UV light

resistant and has excellent dimensional stability. PEI has good resistance to most oils, alcohols, dilute mineral acids, dilute bases and salt solutions.

PBT (polybutyl terphthalate) is a high-strength, rigid polyester. PBT has low creep, even at high temperatures. PBT has excellent dimensional stability and can be moulded into shapes that cannot be attained with other polymers. PBT can be glass-filled to produce a higher strength material. PBT is resistant at room temperature to dilute acids and bases, detergents, aqueous salt solutions, oils, alcohols and many organic solvents. Chemical attacks occur more rapidly at elevated temperature.

PPS (polyphenylene sulfide) is dark opaque. PPS has excellent dimensional stability with low creep and high strength. PPS has good resistance to acids, bases, solvents, alcohols and many organics at elevated temperatures. PPS is attacked slightly by formic acids, some organics and long-term exposures in hot oxidizing agents.

PEEK (polyethetetherketone) is a cream coloured polymer which can be supplied in a limited range of colours. PEEK has excellent flexural and tensile properties at very high temperatures. PEEK is tough and abrasion resistant to attack by a wide range of organic and inorganic chemicals. The only common solvent that attack PEEK is concentrated sulphuric acid and concentrated hydrofluoric acid.

PETG (polyethylene terephthalate-glycol) is and amorphous copolyester. It is clear, strong, tough and dimensionally stable. Although PETG is attacked by esters, ketones and chlorinated solvents, it has better cracking resistance than PC in many other environments.

HPP (high performance polyester) is a clear transparent material with excellent colour ability. The impact strength is equal to or higher than PC.

PAS (polyaryarysulfone) is a high temperature amorphous polymer. Like PES, it has excellent dimensional stability and creep resistance. It is vulnerable to attack by esters, ketones and hydrocarbons. It is chemically resistant to steam, acids, alkalis and salts.

Appendix B Decontamination materials and instructions

Decontamination materials

The following decontamination materials are available in the cleanroom and surrounding areas:

- Full face mask with protective filter
- Protective gloves
- Protective aprons
- Yellow absorbent mat pads
- Absorbent socks
- pH-indicator paper
- Yellow plastic bags

Instructions

1) The cleanroom users are supposed to use the material for small decontamination. Large amount of spill or spill of toxic chemical as well as HF should be decontaminated by the cleanroom staff. Always contact the chemist/staff for detailed instructions.
2) Use proper personal protective equipment
3) Identify the spilled chemical if the contaminant is unknown. Start with the worst possible case (i.e. colour less liquid can be HF).
4) Mix the necessary neutralization solution if needed
5) Neutralize the spilled chemical with its respective neutralizing solution. Use yellow absorbent mat to absorb the spill.
6) Put the contaminated materials into the yellow plastic bags and label the bags with name of contaminant, your name and date
7) Place the bag(s) in a proper fume hood
8) Inform the cleanroom staff

Appendix C Chemical spill clean up

Reference: Reagent Chemicals, MCB Manufacturing Chemists, Inc., 1981, pp. 359-402.

Acids, organic: Apply sodium bicarbonate. Absorb with yellow mat.

Acids, inorganic: Apply sodium bicarbonate/calcium oxide or sodium carbonate/calcium oxide. Absorb with yellow mat. **Note** that hydrofluoric acid is an exception and is described separately.

Acid chlorides: Do not use water. Absorb with sand or sodium bicarbonate.

Aldehydes: Absorb with yellow mat.

Aliphatic amines: Apply sodium bisulfite. Absorb with yellow mat.

Aromatic amines: Absorb with yellow mat. Avoid skin contact or inhalation.

Aromatic halogenated amines: Absorb with yellow mat. Decontaminate with 10% ceric ammonium nitrate solution.

Azides (potentially explosive): Absorb with yellow mat. Decontaminate with 10% ceric ammonium nitrate solution.

Bases (caustic alkalis): Neutralize with acid or commercial neutralizers and absorb with yellow mat.

Carbon disulphide: Absorb with yellow mat.

Chlorohydrins: Absorb with yellow mat. Avoid skin contact or inhalation.

Cyanides: Wet or mist solids before sweeping, or use a HEPA filter vacuum to collect the solids. Absorb with yellow mat or vermicular.

Halides, organic or inorganic: Apply sodium bicarbonate.

Halogenated hydrocarbons: Absorb with yellow mat

Hydrazine: Absorb with yellow mat. Avoid organic matter.

Hydrofluoric acid: Absorb with calcium carbonate (or calcium oxide) rather than sodium bicarbonate. The use of sodium bicarbonate will lead to the formation of sodium fluoride, which is considerably more toxic than calcium fluoride. Be careful in the choice of yellow mats used to absorb the acid. Certain pillows contain silicates that are incompatible with hydrofluoric acid.

Inorganic salt solutions: Apply soda ash.

Mercaptans/organic sulphides: Neutralize with calcium hypochlorite solution. Absorb with yellow mat.

Nitriles: Sweep up solids. Absorb liquids with yellow mat.

Nitro compounds, organic nitros: Absorb with yellow mat. Avoid skin contact or inhalation.

Oxidizing agents: Apply sodium bisulfite.

Peroxides: Absorb with yellow mat.

Phosphates, organic and related: Apply soda ash or sodium bicarbonate. Absorb with yellow mat.

Appendix D Emergency treatment

This appendix describes how to give first aid treatment to people that have been exposed to chemicals.

Inhalation of harmful substances

Symptoms: Coughing, breathing difficulties, wheezing

In the case of inhalation of harmful substances the victim must always be examined by medical personnel. First aid suggestions:

- Remove the patient from the contaminated zone and get to a place with fresh air
- Loosen up tight clothing
- Let the patient rest in a sitting position
- If unconscious the patient should be put in a semi-prone position

Harmful substances in contact with the skin

Symptoms: Burns, nausea, exhaustion

In the case that large areas of the skin have been affected, the patient must always be examined by medical personnel. First aid suggestions:

- Wash the area with copious quantities of water for at least 15 minutes.
- Remove rings, watches and contaminated clothing
- Wash the area with soap and water
- Call Toxin-Information Centre for further information

HF (hydrogen fluoride) exposure

Symptoms: Severity of the damage depends on the amount of exposure and the concentration. Pain is the major symptom. If swallowed it is pain is mostly located in the mouth. Other symptoms are fever, breathing difficulties, vomiting and rapid drop in blood pressure. If inhaled the symptoms are chills, fever, chest pain, coughing and eyes choking. If the skin is exposed to HF the lips and finger nails become bluish.

The patient must always be examined by medical personnel. First aid suggestions:

- Call medical personnel first and seek medical assistance
- After swallowing: Give victim plenty of Calcium Sandoz solution (20 grams per litre of water).
- After inhalation: Fresh air. Keep airways free.
- After contact with skin:
    - Carefully remove contaminated clothing to prevent further exposure

  - Wash the contaminated skin area with copious quantities of water for at least 10 minutes
  - Massage HF antidote gel into the area that was exposed to HF. Repeat continuously until the patient receives medical assistance
- After eye contact:
  - Use the Hexafluorine solution portable eyewash mounted at the acid wet bench within 60 seconds after exposure
  - The solution must not be used as an ocular bath, but as a washing. It must be used in continuing washing, even if the pain has decreased.
  - Maximum time of use recommended to 1 minute maximum

Eyes in contact with harmful liquids

The patient must always be examined by medical personnel. First aid suggestions:

- Wash eyes with copious quantities of water at least 15 minutes at the eye/face wash (wall mount)
- Hold the eyelids apart and wash the area under them
- Keep on washing the eyes (with the eye wash bottle) while transferring the patient to the Eye Clinic

Swallowing of harmful chemicals

Symptoms: Stomach-ache, unconsciousness, nausea and exhaustion

In the case of swallowing of harmful chemicals the patient must always be examined by medical personnel. First aid suggestions:

- Give the patient 1-2 glasses of liquid, preferably water or milk in order to dilute the swallowed chemical. This treatment is not applicable to unconscious patients.
- Avoid any treatment that makes the patient vomit, as this can damage the oesophagus
- If unconscious the patient should be put in a semi-prone position

Toxic poisoning

Early symptoms: Weakness, headache, giddiness, confusion, vertigo, anxiety, nausea, vomiting

First aid suggestions:

- Call Toxin-Information for medical assistance
- Get to a place with fresh air
- In the case of skin contact
  - Remove contaminated clothing, flush the contaminated skin for 15 to 20 minutes with lukewarm water

- In the case of swallowing
  - Vomiting should not be induced. The patient should drink 200-300 ml water. Nothing should be given by mouth if the patient is losing consciousness
- If the patient has difficulty breathing
  - Give Amyl Nitride (0.35 mg). Do as follows:
    - Crush one capsule in a handkerchief and hold the patient's nose for 15-30 seconds for each minute. Repeat for 5 minutes
    - A new capsule shall be used if the blood pressure drops below 80/60. Obtain opinion from medical personnel before application of second capsule.

Appendix E Emergency information

IN EMERGENCY CASES CALL 113

(Ambulance, Rescue Centre, and Toxin-Information)

NOTE: IN THE EMERGENCY CALL, THE HARMED PERSON MUST GIVE THE NAME, CONCENTRATION, VOLUME, AND EXPOSURE-TIME OF THE CHEMICAL / GAS THAT HAS CAUSED THE HARM. THIS INFORMATION WILL HELP THE MEDICAL PERSONAL TO BE WELL PREPARED FOR FURTHER RESCUE.

EMERGENCY TELEPHONE NUMBERS

OTHER IMPORTANT TELEPHONE NUMBERS

AMBULANCE 113

Medical Service (All hours) 113

Ullevål Hospital 22 11 80 80

Eye-Clinic, Ullevål Hospital 22 11 80 80

TOXIN-INFORMATION 22 59 13 00

Medical Service University of Oslo (8.00am – 4.00pm)

22 85 31 74

EMERGENCY Phone UiO 22 85 66 66

EMERGENCY TAXI 22 38 80 50

Appendix F Chemical incompatibility table

The following are chemical incompatibilities that all people who work in the cleanroom should be familiar with in order to avoid mixing chemicals that should not be mixed. The list is from Prudent Practices for Handling and treatment of Chemicals as well as mixing of different chemical wastes. The list should not be considered complete. Questions as to the compatibility of chemicals not listed should be referred to MSDS databases, the chemical manufacturer or current literature.

Acetic Acid: Chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides and permanganates

Acetone: Bromine, chlorine, nitric acid and hydrogen peroxide

Alkaline: Carbon dioxide, carbon tetrachloride and other chlorinated hydrocarbons, water, bromine, chlorine and iodine

Aluminum and its alloys: Acid or alkaline solutions, ammonium persulfate and water, chlorates, chlorinated compounds, nitrates and organic compounds in nitrate/nitrate salt baths

Ammonia (anhydrous): Bromine, chlorine, calcium hypochlorite, hydrofluoric acid, iodine, mercury and silver

Ammonium Nitrate: Acids, metal powders, flammable liquids, chlorates, nitrates, sulphur and finely divided organics or other combustibles

Calcium Oxide: Water

Carbon (activated): Calcium hypochlorite, all oxidizing agents

Caustic soda: Acids (organic and inorganic)

Chlorates or erchlorates: Acids, aluminium, ammonium salts, cyanides, phosphor, metal powders, oxidizable organics or other combustibles, sugar, sulphides and sulphur

Chlorine: Acetone, acetylene, ammonia, benzene, butadiene, butane and other petroleum gases, hydrogen, finely divided metals, sodium carbide, and turpentine

Chromic Acid: Acetic acid, naphthalene, camphor, alcohol, glycerine, turpentine and other flammable liquids

Copper: Acetylene and hydrogen peroxide

Cyanide: Acid

Flammable Liquids: Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, bromine, chloride, fluorine, iodine

Fluorine: Isolate from everything

Hydrazine: Hydrogen peroxide, nitric acid and other oxiding agents

Hydrocarbons: Bromine, chlorine, chromic acid, fluorine, hydrogen peroxide and sodium peroxide

Hydrofluoric Acid: Ammonia, aqueous or anhydrous

Hydrogen Peroxide (anhydrous): Chromium, copper, iron, most metals and their salts, aniline, any flammable liquids, combustible materials, nitromethane and all other organic materials.

Hydrogen Sulphide: Fuming nitric acid, oxidizing gases

Mercury: Acetylene, alkali metals, ammonia, fulminic acid, nitric acid with ethanol, hydrogen, oxalic acid

Nitrates: Combustible materials, esters, phosphorous, sodium acetate, stannous chloride, water, zinc powder

Nitric acid (concentrated): Acetic acid, acetone, alcohol, aniline, chromic acid, flammable gases and liquids, hydrocyanic acid, hydrogen sulphide and nitratable substances

Nitrites: Potassium or sodium cyanide

Oxygen (liquid or enriched air): Flammable gases, liquids or solids such as acetone, acetylene, grease, hydrogen, oils and phosphorous

Perchloric Acid: Acetic anhydride, alcohol, bismuth and its alloys, paper, wood, grease, oils or any other organic material or reducing agent

Peroxides (organic): Acid (inorganic or organic). Also avoid friction and store cold.

Phosphorous (white): Air, oxygen

Phosphorous pentoxide: Alcohols, strong bases, water

Potassium: Air (moisture and/or oxygen) or water, carbon tetrachloride, carbon dioxide

Potassium Chlorate: Sulphuric and other acids

Potassium Perchlorate: Acids

Sodium: See Alkali Metals

Sodium Chlorate: Acids, ammonium salts, oxidizable materials and sulphur

Sodium Nitrite: Ammonia compounds, ammonia nitrate or other ammonium salts

Sodium Peroxide: Any oxidizable substance such as ethanol, methanol, glacial acitic acid, acetic anhydride, benzaldehyde, carbon disulphide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural, etc.

Sulphides: Acids

Sulphur: Any oxidizing materials

Sulphuric Acid: Chlorates, perchlorates, permanganates, compounds with light metals such as sodium, lithium and potassium

Water: Acetyl chloride, alkaline and alkaline earth metals, their hydrides and oxides, barium peroxide, carbides, chromic acid, phosphorous oxchloride, phosphorous pentachloride, phosphorous pentoxide, sulphuric acid and sulphur trioxide.

Appendix G Handling of chemical waste

1) Get a waste container – note that glass bottles shall not be used for hydrofluoric acid
2) The container shall be marked with contact person, phone number, substances, mixture percent and pH. Heavy metals shall be specified in mass percent
3) Place the waste and container in a suitable wet bench and slowly pour the waste into the container
4) If you have mixed two or more compatible in the same container for safety, check if the mixture temperature is elevated. If the temperature is elevated, wait until it has cooled to room temperature.