**Administrative Information**

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| --- | --- | --- | --- |
| School |  | Department |  |
| PI name |  | PI email |  |
| Lab manager name (if applicable) |  | Lab manager email (if applicable) |  |
| Locations covered by this SOP (buildings/rooms) |  | | |
| SOP version number |  | SOP approval date |  |
| Reviewed and approved by (name) |  | Reviewed and approved by (initials) |  |
| **Emergency contact name** |  | **Emergency contact phone\*** |  |
| Secondary emergency contact name |  | Secondary emergency contact phone\* |  |
| \* Provide emergency contact phone numbers that will be active both during normal work hours and after hours, e.g., personal mobile phone. Alternatively, give separate daytime and after-hours numbers for both contacts. | | | |

SOP Requirements

**Instructions Document** You are responsible for reading the [SOP Instructions](https://tiny.cc/usc-sop-instructions) outlining roles, responsibilities, and other important safety information. In addition, you must include that document as part of your records.

**Recordkeeping** Acknowledgement forms for this SOP and any associated training are included at the end of this document. Additional copies of the forms are available online ([SOP Acknowledgement](https://tiny.cc/usc-sop-acknowledgement), [Internal Training Record](https://tiny.cc/usc-sop-training)).

**Customization** It is intended that personnel add lab-specific information to the SOP template to produce a finished and functional SOP. Suggested places to add customization are highlighted in yellow throughout the document.

Standard (Safe) Operating Procedure: OXIDIZING AGENTS

**Hazard and Classification** Oxidizing agents (oxidants) are materials which have a propensity to donate electronegative atoms, most commonly oxygen but sometimes fluorine or chlorine. The donated atoms are able to react with combustible (reducing) materials in an energetic manner. Oxidants intensify combustion, and oxidant-combustible mixtures may be violently reactive, intensely flammable, or explosive. Pyrotechnic reaction or explosion may occur immediately on mixing or spontaneously after a delay, or the mixture may be metastable and unexpectedly ignite or explode on heating, shock, or friction.

Oxidizing agents are relatively common laboratory materials. Examples which may be found in labs include the following:

Oxidizing gases Oxygen, fluorine, chlorine, nitrous oxide, nitrogen dioxide

Oxidizing liquids Perchloric acid, nitric acid, hydrogen peroxide, tetranitromethane, dinitrogen tetroxide

Oxidizing solids Silver(I) oxide, lead dioxide, chromium trioxide, trichloroisocyanuric acid; salts of the following anions: Chromate, dichromate, permanganate, nitrite, nitrate, chlorite, chlorate, perchlorate, bromate, iodate, periodate, peroxide, superoxide; peroxydisulfate (persulfate)

OSHA/GHS classification of oxidizing agents is covered in detail in Section 6 of the [CHP](http://tiny.cc/chem-hygiene-plan), and in the table referenced in the CHP appendices. **All personnel who agree to abide by this SOP are required to familiarize themselves with the contents of Section 6 of the CHP.** In short, oxidizing liquids and solids are assigned into Categories 1-3, where the lower number indicates the more severe hazard. Oxidizing gases are not divided into categories.

**Hazard Identification** For purchased chemicals, identification as oxidizing should be made by assessing the hazard information given in the safety data sheet (SDS). In section 2 of the SDS, look out for the GHS hazard classes of *Oxidizing Solid/Liquid/Gas* and the numeric category (except for oxidizing gases which are not subdivided into categories). Also look for the following Hazard Codes:

*H270 May cause or intensify fire; oxidizer  
H271 May cause fire or explosion; strong oxidizer  
H272 May intensify fire; oxidizer*

Synthesized chemicals should be assumed oxidizing if they contain halogen-halogen bonds, halogen-oxygen bonds, halogen-nitrogen bonds, oxygen-oxygen bonds, or known oxidizing anions (nitrite, nitrate, permanganate, etc). High oxidation state metal oxides and fluorides may also be hazardously oxidizing.

**Bromine and Iodine** Bromine and iodine are not categorized as oxidants by OSHA/GHS, as they do not increase the burning rate of typical organic materials. However, bromine and iodine are powerfully oxidizing towards stronger reductants such as powdered metals and should be handled accordingly.

**Incompatibles** Oxidizing agents are evidently hazardous if mixed with flammable or combustible materials, e.g. organic substances. However, other oxidizable substances not necessarily thought of as combustible may also produce violently flammable or explosive pyrotechnic mixtures with oxidants. Oxidizable substances incompatible with oxidants include: sulfur, phosphorus, arsenic, carbon (e.g. charcoal), boron powder, silicon powder, metal powders (e.g. iron, zinc, aluminum, titanium, zirconium), sulfides, thiosulfates, dithionites, hypophosphites, azides, cyanides, thiocyanates, hexacyanoferrate(II)/(III), carboxylate salts (e.g. acetates), ammonium salts, amine salts, all organic materials, and all non-perfluorinated polymers including silicone resins.

Please refer to [CHP](http://tiny.cc/chem-hygiene-plan) Section 8, subsection *Potentially Explosive Substances*, for more information on incompatible mixtures.

**Special Hazards** Due to potential reactive/explosive hazards, **personnel of limited chemistry knowledge or experience shall NOT attempt to synthesize potentially oxidizing compounds without adequate training, supervision, and oversight from the PI or from an appropriately knowledgeable person delegated by the PI.**

**Do NOT synthesize compounds containing both oxidizing and reducible moieties as they are likely to be explosive.** For example, perchlorate or nitrate salts of metal anions bearing organic ligands are usually powerfully explosive, as are many nitrate esters, nitro compounds, organic peroxides, and all perchlorate esters. Perchlorate or nitrate salts of metal anions bearing hydrazine ligands are explosive.

Do NOT allow aqueous solutions of oxidants (e.g. potassium nitrate solution) to soak into porous combustible material (e.g. paper) and subsequently dry out. On drying, oxidant will crystallize throughout the combustible matrix, resulting in a potentially violently flammable or explosive pyrotechnic mixture.

Do NOT allow aqueous solutions containing both oxidant (e.g. potassium nitrate) and reductant (e.g. potassium hexacyanoferrate(II/III)) to dry out as this may result in deposition of a potentially violently flammable or explosive pyrotechnic mixture of crystals.

**NH3/NH4+ with Oxidants** Ammonia and ammonium cation are oxidizable. Ammonium nitrate, ammonium perchlorate, ammonium chromate/dichromate, and ammonium iodate are all metastable towards energetic decomposition but are safe for laboratory use given appropriate precautions, e.g. not heating or mixing with combustibles. The ammonium salts of other oxidizing anions (e.g. nitrite, chlorate, permanganate) may be unstable, violently explosive, or even spontaneously explosive. **Do NOT mix ammonium salts with nitrites, chlorites, chlorates, or permanaganates.**

**Do NOT mix ammonia or ammonium salts with halogen-donating oxidants (including elemental halogens)** as violently explosive shock-sensitive nitrogen halides may be formed.

**Specific Substances** [Add details of specific substances you will be using in the lab under this SOP.]

For typical work with oxidants, the lab may be considered the designated area provided the lab door signs include appropriate warning pictograms. More hazardous work with oxidants should be done at designated areas within the lab where spillage can be easily contained (e.g. a fume hood) and which should be signed “Warning — Strong Oxidant” (or equivalent wording). If highly hazardous work is being performed, additional signage giving the name of the responsible individual and contact number is also recommended.

**Designated Work Areas /Signage**

Potent liquid oxidants (e.g. nitric acid, perchloric acid, 30% hydrogen peroxide) shall NOT be used where spillage may soak into combustible materials, including wood, paper, and cardboard.

[Add lab-specific work area and signage information here, if needed.]

**Unattended Experiments** Unattended hazardous experiments should be signed according to the requirements of the [Unattended Experiments Fact Sheet](https://tiny.cc/usc-unattended-operations).

**Storage Requirements** Oxidizers should be segregated from flammable, combustible, pyrophoric, water reactive, and reducing materials. Small quantities of inorganic solid oxidizers may be stored in the same cabinet as general inorganics but should be segregated into appropriate secondary containment, which should be clearly marked “oxidizer”. If large quantities of oxidant are required to be stored, a dedicated noncombustible steel cabinet is recommended. Secondary containment (e.g. polypropylene trays) should always be used for storage of liquid oxidizing agents.

Perchloric acid and fuming nitric acid shall NOT be kept in wooden cabinets due to the possibility of spontaneous ignition or explosion.

Hydrogen peroxide shall be stored in the container in which it was supplied and shall be stored upright to prevent liquid escaping through the vented lid. Hydrogen peroxide is preferably stored in a fridge to retard decomposition (2-8 °C recommended).

**Labeling** All hazardous materials not in active use should be appropriately labelled to indicate the hazard. Refer to the [CHP](http://tiny.cc/chem-hygiene-plan) (Section 5) for detailed requirements of hazardous materials labeling. Label templates are available at the [Chemical Labeling and Signage](http://tiny.cc/usc-chm-lbl-sign) web page.

Oxidant storage areas (cupboards, shelves, or secondary containment) should be labelled “oxidant”.

**Personal Protective Equipment**

Appropriate PPE shall be worn for all work with hazardous materials in accordance with the USC [Minimum Standard](https://tiny.cc/usc-ppe-standard), CHP, and [fact sheets](https://tiny.cc/usc-ehs-fact-sheets). Most commonly, research lab PPE consists of a lab coat, eye protection (safety glasses; goggles required if there is a splash hazard), and chemical protective gloves. A face shield may be needed in addition to goggles for severe splash hazards. Note that for reasons of safety and regulatory compliance, respirator usage is NOT permitted outside of the [USC Respiratory Protection Program](https://tiny.cc/usc-ehs-RPP-fs). Please refer to the CHP (Section 8) and [EH&S Fact Sheets](https://tiny.cc/usc-ehs-fact-sheets) for additional information about PPE requirements.

[Add details of any lab- or procedure-specific PPE rules/requirements.]

**Exposure Control** To prevent exposure of personnel, appropriate engineering safety controls (normally a fume hood) shall be used for all work which has the potential to release hazardous vapor or particulates (dust, powder, spray, or liquid or solid aerosol). Please consult the CHP for detailed information on engineering safety controls.

Nitric acid vapor is toxic and many reactions with nitric acid release highly toxic gaseous nitrogen oxides. Nitrogen oxides are also produced by nitric acid in storage. **Nitric acid must only be used in a fume hood. Nitric acid bottles must not be opened outside of a fume hood.** (Very dilute nitric acid may be used outside of a fume hood if necessary but only for reactions which are guaranteed not to produce nitrogen oxides, i.e. NOT things like metal etching.)

Hydrogen peroxide vapor is toxic and may cause lung damage. Hydrogen peroxide should be used in a fume hood unless very dilute (e.g. 3 %).

Secondary containment (e.g. polypropylene trays) should be used for experiments wherever there is potential for significant spillage of oxidants. The depressed working surface of a fume hood constitutes acceptable secondary containment for most work.

**Perchloric Acid Hoods** Mandatory special conditions apply to perchloric acid usage in hoods; please refer to CHP Section 8 for more information.

Hot and/or ≥72% perchloric acid may ONLY be used in a specially engineered perchloric acid fume hood, of which there are a number at USC. These fume hoods incorporate an internal wash-down system. They should be operated in accordance with an SOP based on the manufacturer’s operating manual.

Perchloric acid shall NOT be used in a regular fume hood if the acid is heated or if it is more concentrated than 72%.

**Oxidizing Gas Safety** Incompatible tubing, incompatible gasket materials, and traces of grease or oil may cause fire or explosion in the presence of compressed oxidizing gases. All pipework, fittings, and regulators used with oxidizing gases must be certified as suitable by the manufacturer. Oil, grease, thread sealing compounds, dirt, and other contamination must be scrupulously avoided. Pipework for carrying compressed oxygen must be a specially cleaned grade approved for oxygen service. Non-flammable metal pipework shall be used wherever possible and always for oxidizing gases under any significant pressure above atmospheric. Oxidizing gas systems shall be designed with adequate provision for prevention of reasonably foreseeable hazardous conditions, including backflow, flashback, or mixing of oxidizing and flammable gases.

**Decontamination** All work areas and equipment is to be cleaned and decontaminated after use.

Potentially contaminated PPE shall be removed before entering clean areas. Hands shall be washed before entering clean areas and after completion of work.

[Add details of specific decontamination/cleaning procedures, if needed.]

**Work Practices** Eliminate extraneous flammable/combustible materials from oxidant work areas.

Substitute a less hazardous oxidant when possible.

Design your experiment to use the least amount of material possible to achieve the desired result.

Do not exceed the scale of procedures specified in protocol/procedure section without approval of the PI.

Verify your experimental set-up and procedure prior to use.

[Add details of specific work practices you will be using in the lab under this SOP. Work practices are rules which personnel are required to follow to be safe, for example, that certain procedures may not be done out-of-hours or alone.

Work practices can also be a defined way of doing things, for example, diluting concentrated acids by pouring the acid slowly into water while stirring, with a prohibition on pouring water into the acid.]

**Experimental Procedures** [Add details of specific experimental procedures/protocols you will be using in the lab under this SOP]

**Waste Disposal** Contaminated materials shall be disposed as hazardous chemical waste. Please follow all EH&S directions ([hazmat webpages](http://tiny.cc/usc-hazmat), [fact sheets](https://tiny.cc/usc-ehs-fact-sheets), [CHP](http://tiny.cc/chem-hygiene-plan)). Please email [hazmat@usc.edu](mailto:hazmat@usc.edu) if you have questions that are not answered by EH&S online resources.

[Add details of any lab-specific waste disposal rules.]

**Spill Response** Chemical spill clean-up shall not be attempted if lab personnel do not have proper training and experience, necessary spill kit supplies, and/or appropriate personal protective equipment. **Before starting work, review the** [**Spill Response and Clean-Up**](http://tiny.cc/usc-spill-clnup) **web page and Section 10 of the** [**CHP**](http://tiny.cc/chem-hygiene-plan)**. All personnel operating under this SOP shall familiarize themselves with this information and shall re-review these references at least annually.**

Please refer to the EH&S [Chemical Spill Kit Guide Sheet](https://tiny.cc/usc-ehs-chmSplkit-gs) for guidance on appropriate spill kit materials.

**Call DPS for all spills, even if they get cleaned up by lab personnel.** DPS will pass information to the EH&S and Hazmat on-call system. If needed, trained staff will be sent to the lab to clean and decontaminate the spill. If lab personnel clean the spill themselves, notification should still be made as lab safety specialists may wish to follow up with a routine safety investigation.

**Spills posing a respiratory hazard SHALL NOT be cleaned by lab personnel. Evacuate the area, restrict access, call DPS.**

**Emergency Response** **Before starting work, review the** [**EH&S emergency webpage**](https://tiny.cc/usc-injury) **and the** [**1-2-3 poster**](https://tiny.cc/usc-123)**. Ensure that the 1-2-3 poster is posted in the lab.** **All personnel operating under this SOP shall familiarize themselves with these documents and webpage.**

**All personnel operating under this SOP shall have downloaded and read Section 10 of the** [**CHP**](http://tiny.cc/chem-hygiene-plan) (“*Emergency Response / Injury and Illness Reporting*”). This section provides information on chemical exposure response, spill response, and injury reporting.

**The 1-2-3 poster, CHP Section 10, and the EH&S emergency webpage are hereby incorporated into this SOP by reference.**

**All personnel operating under this SOP shall have the DPS emergency number programed into their phone** (UPC 213-740-4321; HSC 323-442-1000).

**Phone the DPS emergency line in an emergency!!** DPS have 24 h/day immediate communication access to primary and backup personnel on the EH&S and Hazmat on-call rota. **Do NOT call the EH&S general phone line or individual EH&S personnel in an emergency as access is not guaranteed.**

SOP Acknowledgement

The undersigned acknowledge by their signature that they:

1. Have read, understood, have access to, and agree to abide by this SOP, AND;
2. Have read and understood the emergency response resources incorporated into this SOP by reference (“[**1-2-3 poster**](https://tiny.cc/usc-123)”, [**CHP Chapters 6 and 10**](http://tiny.cc/chem-hygiene-plan), and [**EH&S emergency webpage**](https://tiny.cc/usc-injury)), AND;
3. Will download, store, read, and thoroughly familiarize themselves with safety data sheets (SDSs) for all the hazardous materials they intend to use within the scope of this SOP.

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| **Name** | **USC ID** | **Email** | **Signature** | **Date** |
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Internal Training Record

If hazards are high or complex, or personnel have limited prior experience or training, then hands-on training should be provided on the contents of this SOP. For convenience, the training may be documented using this form, although PIs are free to keep internal training records in other formats if desired. Training may be conducted by the PI, or the PI may delegate a suitably experienced and knowledgeable lab member (e.g. lab manager or senior postdoc) as the trainer. If delegated, the PI still retains management responsibility for the quality and adequacy of the safety training.

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| --- | --- | --- | --- |
| Trainer name |  | Trainer position |  |
| Trainer USC ID |  | Trainer email |  |
| Trainee #1 name |  | Trainee #1 USC ID |  |
| Trainee #1 email |  | Trainee #1 signature |  |
| Trainee #2 name |  | Trainee #2 USC ID |  |
| Trainee #2 email |  | Trainee #2 signature |  |
| Trainee #3 name |  | Trainee #3 USC ID |  |
| Trainee #3 email |  | Trainee #3 signature |  |
| Trainee #4 name\* |  | Trainee #4 signature |  |
| Trainee #4 email |  | Trainee #4 USC ID |  |
| Date training started |  | Date training completed |  |
| Type of training (delete as appropriate) | **Initial training**  **Refresher training** | Type of training (delete as appropriate) | **Classroom training**  **Hands-on laboratory training** |
| If refresher training, provide date of initial training |  | If refresher training, was the initial training hands-on in the lab? | **YES 🞏 NO 🞏** |
| Signature of trainer confirming the above named trainees have successfully completed safety training on the contents of this SOP (and any additional subjects listed below) | |  | |
| Date of signing by trainer | |  | |
| Additional subjects covered by safety training |  | | |
| \* If there are more than four trainees, please append an additional sign-in sheet. | | | |