

## Osmium Tetroxide SOP

### Summary

- Osmium tetroxide is highly toxic with acute toxicity and powerful oxidizing ability.
- Purchase and prepare osmium tetroxide in the lowest quantity and lowest concentration whenever possible. Liquid form is recommended.
- Osmium tetroxide solutions must be prepared and handled in a certified chemical fume hood with sash at the lowest possible height.
- Prepare solutions volumetrically.
- Always wear appropriate PPE, including lab coat, safety goggles/glasses, and disposable nitrile gloves. Double-gloving is recommended.
- Triple rinse all containers prior to disposal. Handle spent osmium tetroxide as hazardous waste.

### What is osmium tetroxide?

Osmium tetroxide ( $\text{OsO}_4$ ) is also known as osmium (VIII) oxide. Osmium tetroxide appears as a colorless or yellow (due to presence of the impurity osmium dioxide,  $\text{OsO}_2$ ) solid with a pungent chlorine-like odor. It is volatile and begins to sublime below its melting point (105 °F or 40.6 °C). It is soluble in a wide range of organic solvents. Osmium tetroxide is highly toxic with acute toxicity and powerful oxidizing ability. Osmium tetroxide is most commonly used in oxidation reactions, such as the formation of vicinal diols from alkenes, and for biological staining of lipids. When osmium tetroxide reacts and causes oxidation, it turns black. This may be helpful to know in the event of a splash or spill or inadvertent dermal exposure, as it also can turn oxidized tissue black.

### What are the hazards?

#### **Acute toxicity:**

Osmium tetroxide is highly toxic, and it is a severe irritant of the eyes (i.e., a lachrymator) and respiratory tract. Exposure to osmium tetroxide vapor may damage the cornea of the eye. Irritation is generally the initial symptom of exposure to low concentrations of osmium tetroxide vapor, and can include a gritty feeling in the eyes, cloudy vision, and the appearance of rings and halos around lights. In most cases, recovery occurs in a few days. Concentrations of vapor that do not cause immediate irritation can have an insidious cumulative effects; symptoms may occur several hours after exposure and can include pulmonary edema. Contact of the eyes with concentrated solutions of this substance can cause severe damage and

possible blindness. Inhalation can cause headache, coughing, dizziness, lung damage, difficult breathing and may be fatal. Contact of the vapor with skin can cause dermatitis, and direct contact with the solid can lead to severe irritation and burns. Exposure to osmium tetroxide via inhalation, skin contact, or ingestion can lead to systemic toxic effects involving liver and kidney damage.

### **Chronic toxicity:**

Chronic exposure to osmium tetroxide can result in accumulation of osmium compounds in and damage to the liver and kidney. Osmium tetroxide has been reported to cause reproductive toxicity in animals; this substance has not been shown to be carcinogenic or to show reproductive or developmental toxicity in humans.

### **Occupational Exposure Limits**

OSHA Permissible Exposure Limit (PEL): 0.002 mg/m<sup>3</sup>

NIOSH Recommended Exposure Limit (REL): 0.0002 ppm (0.002 mg/m<sup>3</sup>)

NIOSH REL-Short Term Exposure Limit (STEL): 0.0006 ppm (0.006 mg/m<sup>3</sup>)

ACGIH Threshold Limit Values (TLV): 8-Hr Time Weighted Average (TWA): 0.0002 ppm

ACGIH TLV-STEL: 0.0006 ppm.

Please refer to OSHA 1910.1000 Table Z-1 (<https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1000TABLEZ1>), NIOSH Pocket Guide to Chemical Hazards (<https://www.cdc.gov/niosh/npg/npgd0473.html>) and ACGIH® 2020 Threshold Limit Values for more information.

### **What Activities Could Pose a Risk?**

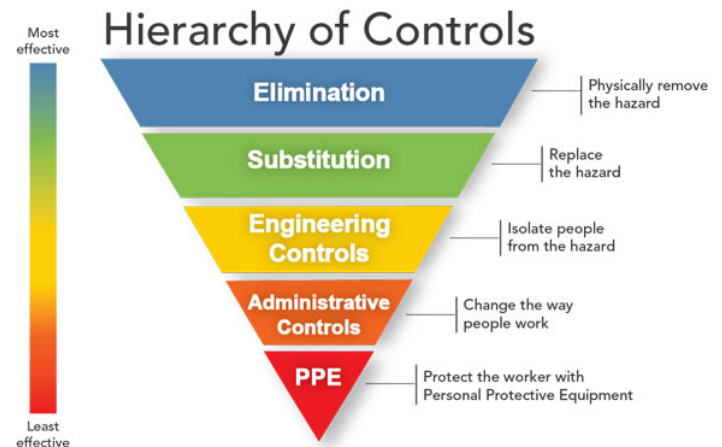
In laboratories, osmium tetroxide is mainly used as a staining agent in transmission electron microscopy. Activities may pose a risk include, but not limited to:

- Handling osmium tetroxide outside of a fume hood.
- Direct contact with osmium tetroxide or biological tissues stained by osmium tetroxide may cause severe damage.
- Using the powdered form of osmium tetroxide may significantly increase risk of inhalation.
- Preparing osmium tetroxide solutions gravimetrically, particularly without use of appropriate engineering controls (i.e., a fume hood).
- Not labeling osmium tetroxide containers clearly.
- Not properly sealing containers of osmium tetroxide.
- Not providing lab specific training regarding osmium tetroxide before handling osmium tetroxide.

- Storing osmium tetroxide next to flammable or combustible substances.
- Not wearing proper PPE when handling osmium tetroxide.
- Storing osmium tetroxide in plastic containers. Osmium tetroxide is capable of reacting with many plastics and the vapor can permeate through these containers leading to exposure.

### How Can Exposures Be Minimized?

When working with osmium tetroxide, or any other hazardous material, always conduct a thorough risk assessment and employ the hierarchy of controls to minimize risk. Some specific applications of the hierarchy of controls to the hazards of osmium tetroxide are listed below. Always apply the controls in the order of most effective to least effective (see graphic), and apply as many controls as possible to reduce the risk to the lowest achievable level.



#### Elimination/Substitution

- Purchase osmium tetroxide in the lowest quantity and lowest concentration whenever possible.
- Prepare the smallest amount of osmium tetroxide solution necessary for the procedure.
- Osmium tetroxide should be purchased as a solution whenever possible. The main application is in the field of electron microscopy. It can be purchased as a 4% aqueous solution or pure 1 g ampoules of crystals. Liquid form is recommended.

#### Engineering Controls

- Osmium tetroxide solutions must be prepared and handled in a recently tested chemical fume hood with the sash at the lowest possible height. Post the hood with a warning sign to alert others to the hazards.
- Work surfaces should be protected with plastic backed absorbent pads (such as the lab mat available for purchase in the Fisher Stockroom) to ensure containment of any spills.

#### Administrative Controls

- Do not work alone. All lab occupants in the area should be made aware of where osmium tetroxide is being handled and emergency procedures.
- Lab specific training should be provided to lab personnel before handling osmium tetroxide that clearly covers the potential hazards and appropriate mitigation techniques.

- Label osmium tetroxide containers clearly. Make sure the container is tightly sealed to prevent the release of vapors.
- Store osmium tetroxide away from hydrochloric acid, flammable or combustible material, and store in sealed glass containers in secondary containment in a refrigerator to reduce the vapor pressure. Osmium tetroxide can penetrate plastics. Sealed glass ampules do not need to be refrigerated.
- Prepare solutions volumetrically (i.e. using solutions) rather than gravimetrically (i.e., weighing solids). If solid material must be used, weighing and other manipulations with the solid must take place in a fume hood.
- Luer-lock or integrated-needle syringes are recommended to perform transfers of osmium tetroxide.
- Wash hands immediately after working with osmium tetroxide.
- Pure osmium tetroxide and concentrated solutions should be stored in a location that is secure to unauthorized access.
- It is recommended to keep corn oil on hand for deactivation in case of a spill.

#### Personal Protective Equipment (PPE)

- Always wear appropriate PPE when handling osmium tetroxide, including lab coat (buttoned and sleeves rolled down), safety goggles/glasses, disposable nitrile gloves. Double-gloving is recommended, especially when working with pure osmium tetroxide or concentrated solutions. Change gloves frequently and when contaminated, punctured, or torn.

#### Waste Handling

All lab waste containing osmium tetroxide should be handled as hazardous waste. This includes contaminated debris (i.e., PPE, plastic, bench covers) that has become heavily contaminated with osmium tetroxide and cannot be cleaned. Osmium tetroxide is an EPA P-listed chemical, which means that empty containers must be triple rinsed, and the rinses must be handled as hazardous waste, prior to disposal. All waste containing osmium tetroxide must be placed in an appropriate container and labeled. The label should indicate all constituents in the waste using a percent format. To have the waste picked up by EH&S staff, complete a Hazardous Materials Pickup Request Form in CEMS.

#### Exposure and Spill Procedure

In the event of a spill involving osmium tetroxide that does not involve the contamination of person, the material may be cleaned up if it is safe to do so.

- Only attempt to clean-up small spills (i.e., 10 mL or less) or contaminated lab equipment inside of a fume hood. Corn oil, sodium sulfide, or sodium sulfite will deactivate osmium tetroxide on labware and on surfaces.

- Place all items used for cleanup in a labeled hazardous waste container and request a pickup through CEMS.
- If at any point you are uncomfortable cleaning up the spill or require assistance, stop and call EH&S (413-545-2682).

Exposures to osmium tetroxide should follow the general procedures for exposures to hazardous materials outlined in the University's Chemical Hygiene Plan.

**For a major exposure requiring the use of a drench shower or eyewash:**

- Have someone call 911 (report the building name, room number, and street address) or 413-545-3111 (or simply 5-3111 from a campus line) to report the incident and request medical help. Have someone obtain the SDS for the material (if there is one) and provide it to the first responders when they arrive, if possible.
- Help the affected individual to position their head over the eyewash and activate it, or position them under the drench shower and activate it as appropriate.
  - Always ensure your own safety before helping others. Only help if it is safe for you to do so.
  - Wear gloves, safety glasses, and a lab coat.
- If using an eyewash: Instruct the affected individual to open their eyes and roll them around while the water is flowing. Help them to hold their eyes open if necessary and safe to do so.
- If using a drench shower: Remove all clothing from the affected area while under the shower.
- Flush the affected area for 15 minutes with water.

**For minor exposures such as a spill to readily accessible extremities (e.g., hand):**

- Flush the affected area in a sink equipped with potable water for at least 15 minutes.
- Go to University Health Services (UHS) for medical evaluation, and tell them you have had a lab exposure.
- Provide the SDS for the material if possible.
- Notify EH&S (413-545-2682) as soon as possible and complete the lab incident form (<https://ehs.umass.edu/lab-incidents-and-lab-incident-report-form>).

**References and Additional Resources**

1. NIOSH Osmium Tetroxide Overview: <https://www.cdc.gov/niosh/topics/osmium-tetroxide/>
2. PubChem database, Compound Summary for Osmium tetroxide: <https://pubchem.ncbi.nlm.nih.gov/compound/30318>
3. UCLA Chemistry and Biochemistry, Standard Operating Procedure Working with Osmium Tetroxide:

[https://www.chemistry.ucla.edu/sites/default/files/safety/sop/SOP\\_Osmium\\_Tetroxide.pdf](https://www.chemistry.ucla.edu/sites/default/files/safety/sop/SOP_Osmium_Tetroxide.pdf)

4. University of Pennsylvania, EHRS, Fact Sheet: Osmium Tetroxide:  
<https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/fact-sheets/fact-sheet-osmium-tetroxide>
5. Boston University, Osmium Tetroxide SOP Template:  
<https://www.bu.edu/researchsupport/compliance/laboratory-safety/high-hazard-chemical-program-2/osmium-tetroxide-sop-template/>
6. Tufts University Standard Operating Procedure (SOP) for Osmium Tetroxide:  
<https://viceprovost.tufts.edu/ehs/files/OsmiumTetroxideSOP.pdf>