Working with Osmium and Ruthenium

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1 Introduction

This document offers a short and concise overview of the use of Osmium tetroxide and Ruthenium tetroxide. Understanding the following content is a crucial prerequisite in understanding basic safety fundamentals such as 1) hazard awareness, 2) engineering controls, 3) work practices, 4) PPE and 5) emergency response for working with these 2 transition metals.

2 Scope

The guideline applies to lab personnel, and it has been developed to assist them in the preparation of lab specific SOPs.

3 Procedure

3.1 Potential hazards of Osmium tetroxide and Ruthenium tetroxide

Osmium tetroxide (OsO_4) and Ruthenium tetroxide (RuO_4) are both strong oxidizing agents.

OsO_4:

- Is highly toxic – ingesting very small amounts can cause death. It is also a severe eye and respiratory irritant – acute exposure can cause severe eye damage, even blindness, or chemical burns to the respiratory tract. It can also cause dermatitis or lung or kidney damage.
- Is not very soluble in water. As a vapor, OsO_4 can cause severe eye damage and irritation to the eye, nose, throat and bronchial tubes, lung, skin, liver and kidney damage.
- In the dry powder form will sublime (pass directly from solid to vapor and back to solid) readily at room temperature and significantly when refrigerated.

RuO_4 cause irritation when inhaled, it is not poisonous to the eyes in contrast to this very serious danger with Osmium tetroxide.

3.2 Incompatibility

- OsO_4 can react with easily oxidized organic materials to cause fires or explosions. It is also incompatible with Hydrochloric Acid (forms poisonous Chlorine gas on contact), 1-methylimidazole (reacts explosively), Aluminum, various metals.
- Keep OsO_4 away from Hydrochloric Acid, other acids, bases, organic materials, metals, strong reducing agents and strong oxidizing agents.
- Contact with combustible material could cause fire.
- Store away from incompatibles.

3.3 Work with OsO_4 and RuO_4

Before starting work:

- Consult the manufacturer's Safety Data Sheet.
- Ensure that a written Standard Operating Procedure experimental protocol including safety information is available.
- Recommended to purchase the liquid form of OsO_4 and NOT the dry powder or concentrated solution.
- Identify the location of the nearest eyewash and safety shower and verify that they are accessible and check that they are working properly.
- Locate and verify that appropriate chemical spill kit is available, including the following:
    - Neutralizer: sodium sulfide or corn oil.
    - Absorbent material.
- Be familiar with the emergency procedures is in the area.

During work:

- Post a warning sign on the fume hood to alert others to that OsO_4 is present.
- Handle OsO_4 always in a certified CHEMICAL fume hood (not biosafety cabinet) to avoid inhalation. Sash lowered as much as possible. Always work at least 15cm (6 inches) into the fume hood and behind the sash. Ensure fume hood baffles are not blocked and there is proper airflow.
- Use appropriate personal protective equipment (PPE) to avoid contact:
    - Wear a lab coat and closed-toed shoes.
    - Wear chemical splash goggles (safety glasses don't offer adequate protection from vapors). If there is risk of splash, also wear a face shield.
    - When using or handling osmium tetroxide, no area of the skin or eyes should be exposed.
    - Nitrile or neoprene gloves (double glove when working with pure or highly concentrated solutions) are generally adequate (consult always the Safety Data Sheet to ensure proper glove selection). Gloves must be thoroughly inspected prior to each use. Change gloves whenever you suspect they have become contaminated (follow the proper glove removal technique without touching glove's outer surface to avoid skin contact). Wash hands thoroughly with soap and water each time gloves are removed.

After completing the work:

- Hazardous Waste Classification: Corrosive and Toxic.
- OsO_4 must be deactivated once work is done and considered hazardous waste.
- A 2% OsO_4 solution will be fully deactivated by two-times the volume of corn oil (corn oil is preferred because of its high percentage of unsaturated bonds).
- All lab glassware as well as surfaces that have contacted OsO_4 should be decontaminated. Pour the corn oil into the OsO_4 solution and wait for the oil to turn completely black. To test if OsO_4 is fully neutralized, hold a piece of filter paper soaked in corn oil over the solution. Blackening of the filter paper indicates that OsO_4 is still present, and more corn oil should be added. The corn oil and OsO_4 solution must be disposed of as chemical hazardous waste.
- Solutions of Sodium Sulfide or Sodium Sulfite will also reduce aqueous solutions of OsO_4 to a less hazardous form. The used solutions must be disposed of as chemical hazardous waste.
- Store in original containers or other appropriate containers.
- Store primary container in designated and compatible secondary containers.
- Wash hands and forearms thoroughly with soap and water before leaving the lab.

3.4 Transportation and storage considerations

- OsO_4 and RuO_4 must be stored at 2°C – 8°C in a chemical refrigerator away from direct sunlight. Do not store in cabinet under the sink.
- Keep away from strong reducing agents, organic materials, powdered metals, HCl (aq) and other acids, bases, strong oxidizing agents.
- Keep all containers tightly closed when not in use and during transport.
- OsO4 dry powder and concentrated solutions should be stored in a secure location (no unauthorized access) in sealed shatter-resistant containers, within secondary containment, during storage and transportation.
- OsO_4 vapors can penetrate plastics, therefore should be stored in sealed glass containers with unbreakable secondary containment.

4 References

- OSHA 3404-11R (2011) – Laboratory Safety Guidance
- KAUST Laboratory Safety Manual
- HSE-RST-Chem001M – Chemical Safety Program
- Wiley Guide to Chemical Incompatibilities
- Handbook of reactive chemical hazards (Bretherick, Leslie Pitt, Martin J. Urben etc.)

5 Help

Questions about this guideline? Contact: hse@kaust.edu.sa