Research Safety
Office of Research
UNIVERSITY OF GEORGIA

Peroxide-Forming Chemicals (PFCs)

Last Reviewed: August 2023

Peroxide-forming chemicals (PFCs) are some of the most potentially hazardous substances handled in laboratories. PFCs are most often flammable organic liquids which are capable of forming potentially explosive organic peroxides upon exposure to air or oxidizing impurities. These organic peroxides can also form on the surfaces of certain alkali metals and their amides. Organic peroxides are sensitive to heat, light or friction and if allowed to accumulate to high enough concentrations can result in explosions. Some chemicals susceptible to peroxide formation have inhibitors such as BHT to prevent peroxide formation, but even these inhibitors can be exhausted over time particularly if a bottle gets opened and closed repeatedly.

For these reasons, peroxide forming chemicals must be monitored very closely. The specifics for how to monitor and check these items vary depending on the class of peroxide former you have in your lab (see the Labeling and Storage section of this SOP). Peroxide levels must be checked regularly and a log of test results maintained.

If you find a peroxide former in your lab and cannot determine a received date and/or opening date or if you notice the formation of crystals, discoloration, cloudiness, film, or stratification of layers take the following actions immediately:

- Do not move or open the container.
- Alert others in lab as to the potential hazard.
- Post a sign warning others not to disturb the container.
- Contact the ESD Hazardous Materials Group at (706) 542-5801 for disposal assistance.

  Instructions for submitting a waste pickup request can be found here.

Personal Protective Equipment

Lab Coat

Standard lab coats are required. Flame resistant lab coats should be considered when handling flammable liquids and other hazardous materials that are easily ignited.

Gloves

Nitrile or chloroprene gloves typically provide adequate protection against minor splashes. Consult with your PI or supervisor to determine whether any materials involved in your process require alternative hand protection.

Eye Protection

ANSI Z87.1 - Compliant safety glasses or safety goggles if a splash hazard is present.

Labeling & Storage

PFCs should be stored away from light. The ideal location is in a flammable storage cabinet with self-closing hinges or in a refrigerator rated for flammable storage. If this is not possible then consider keeping the solvent in a light-blocking bottle (e.g., amber glass). All PFCs must be stored away from oxidizers and should be marked with receiving date and opening date. If the receiving and opening date is not known, promptly dispose of as hazardous waste. They should be purchased in limited quantities with older materials used first. Additionally, they must be managed in accordance with the following guidelines:

Class A: Chemicals that form explosive levels of peroxides without concentration, even if unopened.

Storage and Management: Date upon receipt and upon opening. If unopened from manufacturer, keep up to 18 months or stamped expiration date, whichever comes first. After opening, it is recommended that these chemicals be discarded or evaluated for peroxides no more than **3 months** after opening. If crystals are visible in the solvent or around the cap or (in the case of alkali metals and their amides), if you notice film or discoloration on the surface, follow the instructions on the first page of this SOP.

Organic
Divinyl ether
Isopropyl ether
Divinyl acetylene
Vinylidene chloride

Inorganic
Potassium metal
Potassium amide
Sodium amide (sodamide)

Class B: Chemicals that are a peroxide hazard when concentrated through evaporation or distillation.

Storage and Management: Date upon receipt and upon opening. After opening, materials must be discarded or evaluated for peroxides within 12 months and every 6 months thereafter. If a bottle reaches its expiration date and remains unopened, the laboratory is required to either dispose of the bottle or open it and begin testing it every 6 months. At any time, if crystals are visible in the solvent or around the cap, follow the instructions on the first page of this SOP.

Acetal	Dicyclopentadiene	Isopropanol*
Cumene	Diethylene glycol dimethyl ether	Methyl acetylene
Cyclohexene	Diethyl ether	Methyl cyclopentane
Cyclooctene	Dioxane (*p*-dioxane)	Methyl -I-butyl ketone
Cyclopentene	Ethylene glycol dimethyl ether	Tetrahydrofuran
Diacetylene	Furan	Tetrahydronapthelene
		Vinyl ether

**Due to the near universal use of isopropyl alcohol combined with its reduced hazard of peroxide formation, laboratories are allowed to avoid the test strip requirement if the following management requirements are met:*

- *Laboratories must never use isopropanol for procedures involving distillation and evaporation.*
- *Isopropanol must be stored in non-light penetrating containers (e.g., amber bottles). If light-penetrating containers are provided from the manufacturer, then those containers must always be stored in flammables cabinets or some other location not exposed to light.*
- *If isopropanol is transferred into non-original containers, these containers must be labeled appropriately and dated with a fill date. At six months past the fill date, testing of the solution with a test strip must begin until the bottle is refilled.*

Class C: Chemicals that may autopolymerize as a result of peroxide accumulation.

Acrylic acid	Methyl methacrylate	Vinyl acetylene
Acrylonitrile	Styrene	Vinyl chloride
Butadiene	Tetrafluoroethylene	Vinyl pyridine
Chloroprene	Vinyl acetate	Vinylidene chloride
Chlorotrifluoroethylene		

Storage and Management: Date upon receipt and upon opening. If unopened from the manufacturer, keep up to 18 months or stamped expiration date, whichever comes first. After opening, materials with inhibitors must be discarded or evaluated for peroxides within 12 months; chemicals without inhibitors must be discarded as hazardous waste as soon as possible after the container is opened. If crystals are visible in the solvent or around the cap or (in the case of alkali metals and their amides), if you notice film or discoloration on the surface, follow the instructions on the first page of this SOP.

Peroxide Testing

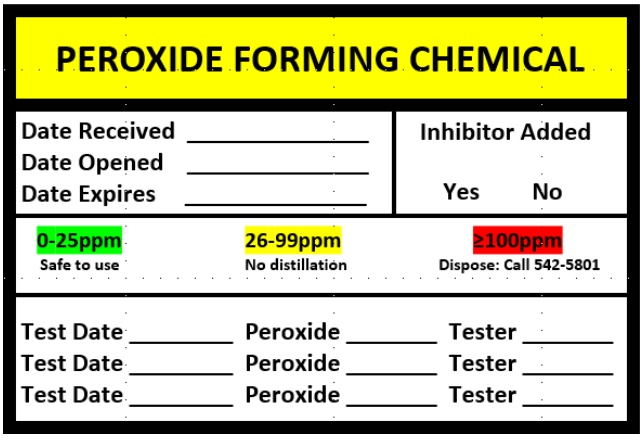
If test strips are to be employed to determine peroxide levels, they should cover the range from 0 – 100 ppm. The following peroxide levels must be used to determine activities that are deemed safe.

0-25 ppm - Material is safe to use or distill.
26-99 ppm - Material is safe to use but should not be distilled.
Above 100 ppm - Material should be disposed of and not used in lab.

A visual check will be necessary for solid peroxide formers (for which testing strips are not appropriate). A visual test must check for the following:

- Discoloration
- Film or crust on the surface

Any time a test (including a visual check) is done on a substance, it must be documented. ORS provides the labels below and will affix these to containers as they are found in the lab during inspections. These labels can also be requested by lab staff at any time. For a test conducted with strips, write the level in ppm in the blank space provided. For a visual test conducted on a solid substance, write "Vis" or "V" in the blank space provided.



Engineering Controls, Equipment & Materials

Fume Hood

Use a fume hood to keep exposure as low as possible when using these chemicals. A blast shield may also be considered in certain situations (e.g., distillations). If your protocol does not permit the handling of such materials in a fume hood, contact the Office of Research Safety

(ORS) to determine whether additional respiratory protection is warranted.

Cautions & Considerations	
Static Electricity	When transferring flammable liquids between containers greater than 4L (1 gallon) containers should be grounded, and the source container should be bonded to the receiving container during transfer. If possible, transfer flammable chemicals from glass containers to glassware or from glass container/glassware to plastic. Transferring these types of chemicals between plastic containers or unbonded metal containers may lead to a fire hazard due to static electricity.
Housekeeping	
Spills	Please refer to Spill Control Guidelines for detailed information.
Decontamination	Once any standing material has been wiped away, clean contaminated surfaces with soap and water. Dispose of contaminated paper towels as solid hazardous waste.
Waste	Any waste from this chemical class should be disposed of through the UGA Hazardous Waste Program. For assistance with arranging a waste pickup, you may contact the Environmental Safety Division (ESD) at 706-542-5801. Prior to pickup, any container used to hold hazardous waste should be labeled with the following: - "Hazardous Waste" - Chemical contents: Enough detail should be provided so that the full contents of the container are readily apparent. Labeling may include any of the following: • Percentages (Ex: 70% water, 30% hydrochloric acid) • Volumes (Ex: 1L of acetone, 500mL of water) • Chemical classes (Ex: halogenated solvents) • Method (Ex: EPA 515.1 Herbicide Extraction Solvent Waste) • Referenced Log (Ex: See Laboratory Waste Log, Volume 2)

	• Utilizing Chematix waste profiles • Any other labeling method providing enough detail to accomplish this requirement
	One or more of the following waste characteristics recognized by EPA: Ignitable, Corrosive, Reactive, or Toxic.

First Aid & Emergencies

Fire	Use a Class BC or CO_2 extinguisher to put out a small fire.
Skin | Eye Contact	Remove contaminated clothing and accessories; flush affected area with water. If symptoms persist, get medical attention.
Inhalation	Move person into fresh air. If symptoms persist, get medical attention.
Ingestion	Rinse mouth with water. If symptoms persist, get medical attention.

References

"Reconsidering the Safety Hazards Associated with Peroxide Formation in 2-Propanol," Organic Process Research & Development, American Chemical Society, December 2022, Vol. 26, pages 1558-1561.

Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, National Research Council, 2011

"Management of Time Sensitive Chemicals: Their Identification, Chemistry, and Management," Chemical Health & Safety – American Chemical Society, November 2004, 17-24.

"Peroxides and Peroxide-Forming Compounds," Chemical Health & Safety – American Chemical Society, September 2001, 12-22.

"Review of Safety Guidelines for Peroxidizable Organic Chemicals," Chemical Health & Safety – American Chemical Society, 1996, 4(5), 28-36.

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Contacts

Office of Research Safety: 706-542-5288
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