UNIVERSITY OF TEXAS ARLINGTON | ENVIRONMENTAL HEALTH & SAFETY

Standard Operating Procedure
Peroxide-Forming Chemicals (PFCs)

Purpose
The purpose of this SOP is to guide Principal Investigators (PIs)/Chemical Owners and laboratory users in the safe handling of Peroxide-Forming Chemicals (PFCs).

Search and Updates on CEMS
To search for PFCs in your laboratory, go to CEMS at http://cems.uta.edu, load the chemical inventory of your lab, and filter the Hazards-column for "Peroxidizable". Remember to enter the date of opening, the date of testing, and peroxide level testing results into the Container Notes of each Container Record of a PFC.

Introduction
Certain chemicals can react with oxygen to create peroxides. Concentrated peroxides can explode with impact, heat, or friction. PFCs can be divided into hazard classes that are based on the method of reaction. This document outlines how to store, handle, and test for the presence of peroxides. PIs are responsible for following these guidelines for the control and safe use of PFCs.

Maximum Storage Time for PFCs

Unopened chemical containers from manufacturer:	18 months

***Opened chemical containers from manufacturer:**	
Chemicals in Table A	3 months
Chemicals in Tables B and D	12 months
Uninhibited chemicals in Table C	24 hours
Inhibited chemicals in Table C (do not store under an inert atmosphere)	12 months

**If a chemical container is not labeled with the date on which it was opened, the opened date will default to the date at which the chemical was received.*

TABLE A: Severe Peroxide Hazard. These chemicals can spontaneously decompose and become explosive after exposure to air, even without concentration. These chemicals must be stabilized or decontaminated and discarded **within 3 months of opening**.

Butadiene (liquid monomer)	Potassium metal
Chloroprene (liquid monomer)	Sodium amide
Divinylacetylene	Tetrafluoroethylene (liquid monomer)
Isopropyl ether	Vinylidene chloride
Potassium amide	

TABLE B: Concentration Hazard. These chemicals require external energy for spontaneous decomposition. They form explosive peroxides when distilled, evaporated, or otherwise concentrated. Discard these chemicals **within 12 months of opening**.

Acetal	2-Hexanol
Acetaldehyde	Methylacetylene
Benzyl alcohol	3-Methyl-1-butanol
2-Butanol	Methylcyclopentane
Cumene	Methyl isobutyl ketone
Cyclohexanol	4-Methyl-2-pentanol
2-Cyclohexen-1-ol	2-Pentanol
Cyclohexene	4-Penten-1-ol
Decahydronaphthalene	1-Phenylethanol
Diacetylene	2-Phenylethanol
Dicyclopentadiene	2-Propanol
Diethyl ether	Tetrahydrofuran
Diethylene glycol dimenthyl ether (diglyme)	Tetrahydronaphthalene
Dioxanes	Vinyl ethers
Ethylene glycol dimethyl ether (glyme)	Other secondary alcohols
4-Heptanol	

TABLE C: Shock and heat sensitive. These chemicals are highly reactive and can auto polymerize as a result of internal peroxide accumulation. The peroxides formed in these reactions are extremely shock and heat sensitive. Inhibited chemicals in this group should be discarded **within 12 months of opening**. Uninhibited chemicals in this group should be discarded **within 24 hours of opening**.

Acrylic acid	Tetrafluoroethylene (gas)
Acrylonitrile	Vinyl acetate
Butadiene (gas)	Vinylacetylene (gas)
Chloroprene	Vinyl chloride (gas)
Chlorotrifluoroethylene	Vinylpyridine
Methyl methacrylate	Vinyladiene chloride
Styrene	

TABLE D: Chemicals that may form peroxides but cannot clearly be placed in tables A-C. **Discard these chemicals within 12 months of opening.**

Acrolein	2,4-Dinitrophenetole
Allyl ether	1,3-Dioxepane
Allyl ethyl ether	Di(1-propynyl)ether
Allyl phenyl ether	Di(2-propynyl)ether
p-(n-Amyloxy)benzoyl chloride	Di-n-propoxymethane
n-Amyl ether	1,2-Epoxy-3- isopropoxypropane
Benzyl n-butyl ether	1,2-Epoxy-3- phenoxypropane
Benxyl ether	p-Ethoxyacetho-phenone
Benzyl ethyl ether	1-(2-Ethoxyethoxy)-ethyl acetate
Benzyl methyl ether	2-Ethoxyethyl acetate
Benzyl 1-napthyl ether	(2-Ethoxyethyl)-o-benzoyl benzoate
1,2-Bis(2-chloroethoxy)- ethane	1-Ethoxynaphthalene
Bis(2 ethoxyethyl)ether	o,p-Ethoxyphenyl isocyanate
Bis(2(methoxyethoxy)- ethyl) ether	1-Ethoxy-2-propyne
Bis(2-chloroethyl) ether	3-Ethoxyopropionitrile
Bis(2-ethoxyethyl) adipate	2-Ethylacrylaldehyde oxime
Bis(2-ethoxyethyl) phthalate	2-Ethylbutanol
Bis(2-methoxyethyl) carbonate	Ethyl B-ethoxy- propionate
Bis(2-methoxyethyl) ether	2-Ethylhexanal
Bis(2-methoxyethyl) phthalate	Ethyl vinyl ether
Bis(2-methoxymethyl) adipate	Furan
Bis(2-n-butoxyethyl) phthalate	2,5-Hexadiyn-1-ol

Bis(2-phenoxyethyl) ether	4,5-Hexadien-2-yn-1-ol
Bis(4-chlorobutyl) ether	n-Hexyl ether
Bis(chloromethyl) ether	o,p-Iodophenetole
2-Bromomethyl ethyl ether	Isoamyl benzyl ether
B-Bromophenetole	Isoamyl ether
o-Bromophenetole	Isobutyl vinyl ether
p-Bromophenetole	Isophorone
3-Bromopropyl phenyl ether	B-Isopropoxy- propionitrile
1,3-Butadiyne	Isopropyl
Buten-3-yne	Limonene
Tert-Butyl ethyl ether	1,5-p-Methadiene
Tert-Butyl methyl ether	Methyl p-(n-amyloxy) benzoate
n-Butyl phenyl ether	4-Methyl-2-pentanone
n-Butyl vinyl ether	n-Methylphenetole
Chloroacetaldehyde diethylacetal	2-Methyltetra-hydrofuran
2-Chlorobutadiene	3-Methoxy-1-butyl acetate
1-(2-Chloroethoxy)-2- phenoxyethane	2-Methoxy-ethanol
Chloroethylene	Methonxy-1,3,5,7- cyclooctatetraene
Chloromethyl methyl ether	B-Methoxy-propionitrile
B-Chlorophenetole	m-Nitro-phenetole
o-Chlorophenetole	1-Octene
p-Chlorophenetole	Oxybis(2-ethyl acetate)
Cyclooctene	Oxybis(2-ethyl benzoate)
Cyclopropyl methyl ether	B,B-oxydi-propionitrile
Diallyl ether	1-Pentene
p-Di-n-butoxybenzene	Phenoxyacetyl chloride
1,2-Dibenzyloxyethane	a-Phenoxy-propionyl chloride
p-Dibenzyloxybenzene	Phenyl o-propyl ether
1,2-Dichloroethyl ethyl ether	p-Phenylphenetone
2,4-Dichlorophenetole	n-Propyl ether
Diethoxymethane	n-Propyl isopropyl ether
2,2-Diethoxypropane	Sodium 8,11,14-eicosa-tetraenoate
Diethyl ethoxymethylene- malonate	Sodium ethoxyacetylide
Diethyl fumarate	Tetrahydropyran
Diethyl acetal	Triethylene glycol diacetate
Diethyketene	Triethylene glycol dipropionate
m,o,p-Diethoxybenzene	1,3,3-Trimethoxy- propene
1,2-Diethoxyethane	1,1,2,3-Tetrachloro-1,3- butadiene

Dimethoxymethane	4-Vinyl cyclohexene
1,1-Dimethoxyethane	2,4,5-tri- chlorophenoxyacetate
Dimethylketene	Vinylene carbonate
3,3-Dimethoxypropene	Vinylidene chloride

NOTE: These tables represent prominent organic and inorganic compounds that are able to form peroxides under the right conditions. The tables are not comprehensive. You should refer to the Safety Data Sheet (SDS) or other reference material, contact the chemical manufacturer, or contact EH&S (817-272-2185) to determine if the chemicals you are using are potential PFCs.

General Precautions for Storage and Handling of PFCs

1. Know the properties and hazards of all chemicals you are using through adequate research and study. Read the label and Safety Data Sheet (SDS).

2. Wear proper personal protective equipment, including safety glasses, face shield, lab coat, gloves, and if possible utilize a safety shield.

3. Segregate PFCs from incompatible materials.

4. Store PFCs away from ignition sources. Protect PFCs from flames, static electricity, and other sources of heat.

5. Purchase PFCs with inhibitors added by the manufacturer whenever possible.

6. Do not purchase large quantities of PFCs. Purchase only the amount that you will use in a 3-month period.

7. Date all PFCs upon receipt and again upon opening.

8. DO NOT OPEN a container of a PFC that has obvious crystal formation or liquid stratification. Do not handle the container or force open the lid. Treat the reagent as potentially explosive material. Immediately call EH&S for assistance (817-272-2185).

9. Store PFCs (especially those in Table A) under nitrogen or other inert gas, or keep and use them in an inert atmosphere chamber.

   Note: Some inhibitors actually need small amounts of oxygen to prevent peroxide formation and it is recommended that inhibited chemicals are not stored under an inert atmosphere.

10. Store PFCs in sealed, air-impermeable containers such as dark amber glass with a tight-fitting cap. DO NOT store these chemicals in open, partially empty, or

transparent containers as these conditions promote formation of peroxides. Containers of PFCs should also be stored away from heat and light and protected from physical damage and ignition sources.

11. Avoid distillation of PFCs without first testing for the presence of peroxides in the material. Most explosions with the use of PFCs occur when a material is distilled to dryness. Leave at least 10-20% of PFC undistilled. Stir such distillations with a mechanical stirrer or a bubbling inert gas. Air or an oxygen-containing mixture should never be used for bubbling or stirring.

Quantitative Peroxide Testing

- You can purchase Peroxide Test kit/sticks/strips from most safety or laboratory supply houses. Some examples include Sigma-Aldrich, Fisher Scientific, and VWR Scientific.

- Wear proper personal protective equipment, including safety glasses, face shield, lab coat, gloves, and if possible utilize a safety shield.

- Perform testing in a chemical fume hood.

- Make sure there are no solids or crystals in either the liquid or around the cap of PFC. If they are present do not open or move the container. Contact EH&S (817-272-2185) for disposal.

- To use most Peroxide Test sticks/strips, simply immerse the stick/strip into the suspect material and then compare the color on the strip to the calibration chart that comes with the test kit. This gives a quantitative peroxide concentration, usually in ppm.

  Caution: these strips have finite ranges. You may need to buy several different test kits to cover all possible ranges; read the product information or call the manufacturer for more information.

- PFCs must be tested for peroxide concentration upon opening and every three months thereafter.

- Correctly fill out the label shown below and attach it to the container.

Container Labeling Instructions

Researchers must date each container with a PFC upon arrival in the laboratory. Containers must be dated again when opened for the first time. EH&S can provide the label below upon request.

Example:

PEROXIDE FORMING CHEMICAL

Date Received__11/27/2019 **Date Opened**__1/27/2020
Date/Test Results__1/27/2020 0 ppm_____
Date/Test Results__4/27/2020 50 ppm_____
Date/Test Results__7/27/2020 100 ppm_____

The example chemical was opened within the 18 months allowable unopened storage time. The initial test after opening was satisfactory. Subsequent tests every three months were satisfactory until the test on 7/27/2020, as this test result was 100 ppm. At that time the chemical must be disposed of as soon as possible.

Disposal of PFCs

PFCs must be disposed of if they have a peroxide concentration greater than or equal to 100 ppm, or when the maximum storage time limit is reached. See the table “Maximum Storage Time for PFCs” on page 1 of this document to determine when a PFC should be discarded. If within the storage time frame and no crystal formation or liquid stratification is evident, these chemicals can be properly disposed through UTA’s normal waste disposal procedure. Submit Waste Pickup Request via CEMS http://cems.uta.edu.

If crystals are present in either the liquid or around the cap of the container with PFC do not open or move the container. Contact EH&S at 817-272-2185 for disposal.