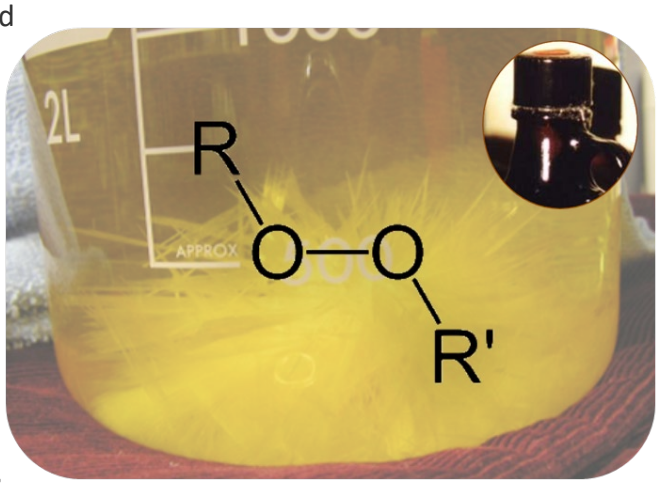
PEROXIDE FORMERS

STANDARD OPERATING PROCEDURES

GENERAL SUMMARY

Peroxide-forming chemicals (PFC's) contain an oxygen-oxygen single bond and can form **shock-sensitive explosive** crystals when exposed to certain conditions or left for extended times. Evidence of peroxide formation can include crystalline solids in the liquid itself or around the cap. These crystals **may explode when subjected to heat, light, friction or mechanical shock (e.g. unscrewing the cap**). It is particularly dangerous to allow these materials to evaporate. Peroxide forming chemicals include solids, liquids, and gases and may also be flammable or reactive, so always consult the Safety Data Sheet of the chemical you plan to use. **Peroxides form after exposure to air at a rate which is dependent on the specific chemical, the amount of air exposure, and whether the chemical contains an inhibitor**.



There are three classes (A-C) of potentially peroxide-forming chemicals defined below, along with their storage limitations.

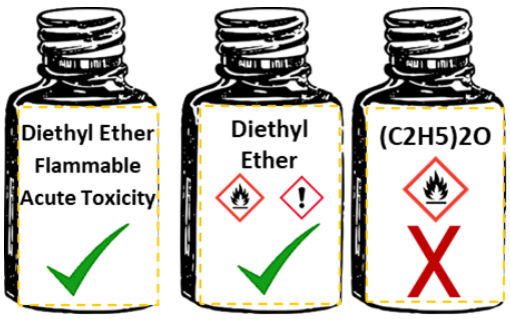
PLANNING CONSIDERATIONS

- **Use a less hazardous chemical**, if possible.
- Purchase the **quantities** of peroxide-forming chemicals that you expect **to use within expiration and disposal timeframes**.
- Purchase peroxide-forming chemicals **containing a peroxide formation inhibitor** (e.g., tetrahydrofuran or diethyl ether inhibited with butylated hydroxytoluene (BHT)).
- **Verify all work areas** have appropriate engineering controls in place.

LABELING REQUIREMENTS

Chemical containers **must be labeled** with:

- **Full chemical name** and all **hazards.**
- **Date received** and **opened. Date Tested,** if applicable; **labels** are **available** through EHS & EM.
- Labels should be **legible** and in **good condition**.
- Regularly check chemical stock to **verify chemicals are labeled properly.**



ENGINEERING CONTROLS

Single pass ventilation, where 100% of the air is pulled from outside and directly exhausted back out, should be provided to areas where peroxide-forming chemicals are handled or stored.

Chemical Fume hoods are required when working with peroxide-forming chemicals. If a chemical fume hood is not available, glove boxes or other appropriate containment devices may be used.

Check that your fume hood is in working order by:

- Verifying the **certification** date is in the past year.
- Check the flow monitor is between **80 and 120 FPM.**
- Test the hood alarm to ensure correct function.
- Contact EHS&EM if hood is not functioning properly.

Work safely in a fume hood by:

- Working with the **sash as low as practicable**, never above 16."
- **Working 6" into the depth** of the cabinet, not on the edge.
- Keeping **bulky equipment outside the hood** if possible.

Emergency showers, eye washes, and/or eyewash/drench hose units must be available. A weekly operational check of the eyewash stations is required and the path to all emergency equipment should be **free of any obstructions**.

ADMINISTRATIVE CONTROLS

Always Use Good Lab Safety Practices!

- **No Food or drink**
- **Wash Hands**
- **Clean after yourself**
- **Label fridges and ice machines "Lab Use only"**
- **Utilize appropriate PPE**
- **Never reuse disposable gloves**
- **Don't work alone**

- Design procedures to:
  - **Minimize contact and exposure time**
  - **Minimize open container work**
- Designate and label work areas with **limited access**
- Complete all relevant **training**
- Know the location of all **emergency equipment**
- **Never leave experiments unattended**
- Do not allow materials to evaporate to near dryness
- Perform **liquid transfers** slowly using a **funnel** to minimize splash, splatter, and spills; for **small volumes** utilize luer-lock, integrated-needle syringes or mechanical pipettes
- Ensure all **containers/materials are compatible** for proposed use. **Do not use metal spatulas or magnetic stirring bars** with peroxide forming chemicals
- Use a spreadsheet, list, or inventory management tool to keep **track of PFC's and relevant dates**

PERSONAL PROTECTIVE EQUIPMENT

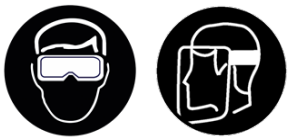
Remove all PPE before leaving the lab; don't touch common items (e.g., doorknobs) with gloves on.

HANDS

- **Gloves are always required.**
- **Always check glove compatibility** with the specific chemical in use.
- If working with a chemical with high dermal toxicity, **double-glove.**
- **Change gloves** when contaminated or damaged.

EYE & FACE

- **Safety glasses** required.
- **Safety goggles and/or a face shield** must be worn when **testing peroxide levels**, transferring large volumes, and in other situations where a splash or aerosols are likely (e.g., transfer of liquids outside of a fume hood).



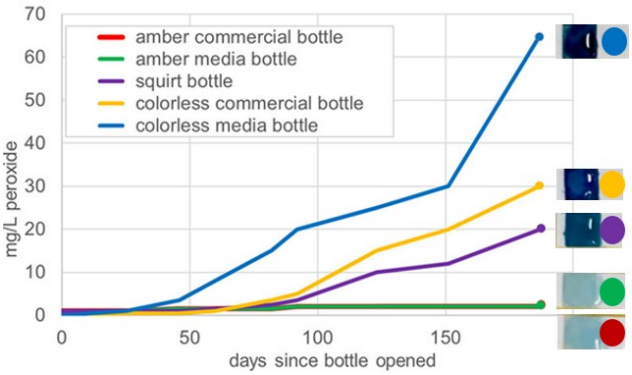
SKIN

- **Lab coat**, fastened with sleeves extending to the wrists is required.
- **Long pants** and **close-toed shoes** are required.
- Use a **rubber apron** when handling large volumes or there is a high splash risk.

STORAGE REQUIREMENTS

- Store in **light-resistant** containers.
- Store in the **original manufacturer's container** whenever possible. This is very important in the case of diethyl ether because the iron in the steel containers that the material is shipped in acts as a peroxide inhibitor.
- Keep containers **tightly closed**.
- Store in **shatter-resistant containers** in **secondary containment**.
- Store in a **well-ventilated** area away from light, heat sources and combustible materials.
- Do not store potentially hazardous material **under sinks or above eye level**.
- Regularly **check containers** for cracks/warping, testing dates, and expiration dates.
- **Do not store with incompatible chemicals**: Keep away from all organic reagents and solvents; Separate acids and bases; inorganic acids and organic acids. Access our compatibility flyer here.

PEROXIDE TESTING



Stabilized peroxide formers should be periodically tested for the presence of peroxides. For chemicals that have been determined to be safe to open, **measure the peroxide concentration** using commercial peroxide test strips (e.g., Quantofix Peroxide Test Strips (CTL Scientific Supply) and (MilliporeSigma)). **Laboratory personnel are responsible** for performing peroxide testing of chemicals present in their labs or storage areas. While there is uncertainty regarding the concentration at which peroxides pose a hazard, solutions with a peroxide concentration below **25 mg/L** are considered safe for general use while those with a concentration between **25 and 100 mg/L** should **not be distilled or concentrated**; Solutions with a **concentration over 100 mg/L** should be discarded as hazardous waste.

Peroxide formers should be tested for peroxide content or disposed as hazardous waste based on the suggested shelf life for its peroxide forming classification (**see table below**). Materials lacking a manufacturer's expiry date and are older than the suggested shelf life with **no detectable peroxides may be retained** but should be **re-tested** every **three months**. All chemicals that will be **distilled must be tested** prior to distillation **regardless of age**.

Never test containers of unknown age or origin. Older containers are far more likely to have concentrated peroxides or peroxide crystallization in the cap threads and therefore can present a serious hazard when opened for testing.

WASTE DISPOSAL

- Do **not** dispose of peroxide-formers in **sinks or sewer drains**. Refer to App State's Drain Disposal Guidance if you are unsure on whether a chemical can be discarded into the drain or must be collected for disposal.
- **Store** hazardous waste in **chemically compatible containers** (**light resistant**) within the designated waste area.
- Dispose of **expired** peroxide formers, **rusted** containers, and any peroxide former with **visible discoloration, crystallization, or liquid** stratification promptly.

- Ensure **structural integrity** of containers until pick up**.**
- Keep containers **capped tightly** and use **secondary containment**.
- **Separate** waste by hazard class and compatibility.
- **Label** with an Appalachian State hazardous waste label prior to pick up.
- Waste should be neutralized before pickup, if possible.

CONTACT **EHS & EM AT (828) 262-4008** FOR CHEMICAL WASTE COLLECTION OR REGULATORY GUIDANCE.

EMERGENCY INFORMATION:

FIRE:

Evacuate the building immediately, pulling the fire alarm on the way out. Meet at your building's assembly point and contact emergency personnel (University Police- 828-262-8000 or 911). Follow instructions and advise emergency personnel of the situation. When able, contact the primary and secondary emergency contacts listed in the Lab Safety Plan.

SPILLS:

Do not clean the spill unless trained. Evacuate the area if the spill is fuming or irritating to the respiratory tract or eyes/skin. Contact emergency personnel (University Police- 828-262-8000 or 911). Follow instructions and provide information such as location, chemical name & hazards, amount released, etc. When able, contact the primary and secondary emergency contacts listed in the Lab Safety Plan.

EXPOSURE:

Consult the Lab-Specific procedures to identify and follow any exposure procedures for the specific chemical in question. If no specific procedures are listed, for spills on the body, in the eye, or in an open wound, find and activate the nearest emergency shower or eyewash station. Immediately discard any contaminated clothing. Stand in the emergency shower stream or use the eyewash/drench hose to stream water over the affected areas for at least 15 full minutes. Contact emergency personnel (University Police- 828-262-8000 or 911) using the Safety Data Sheet of the chemical to communicate the hazards with medical professionals. When able, contact the primary and secondary emergency contacts listed in the Lab Safety Plan.

EMERGENCY CONTACT INFORMATION

Appalachian Police Department..... (828) 262-8000
Environmental Health, Safety, and Emergency Management ..... (828) 262-4008
Watauga Medical Center ..... (828) 262-4100
Poison Control Center ..... (800) 222-1222

Peroxide Forming Chemical Classifications

	A	B	C
Description	Severe peroxide hazard after prolonged storage, especially after exposure to air. Chemicals in this group can form amounts of peroxides that can cause an explosion without concentration. All listed chemicals have been responsible for fatalities.	Chemicals in this group form amounts of peroxides that do not normally cause an explosion, but they can pose an explosion hazard when concentrated by evaporation or distillation. Most of these solvents are sufficiently volatile that multiple openings of a single container can result in a significant and dangerous peroxide concentration.	Peroxide formation can initiate explosive auto-polymerization. The peroxide-forming potential is higher for liquids than for gases in this group.
Storage & Use	Test liquids for peroxide formation before using, and discard when peroxides are present. Discard 3 months after opening. Discard unopened chemicals after storage for 12 months.	Store in a dark location. Test for peroxide formation every 12 months after opening or dispose of the chemical as hazardous waste. Additionally, always test before distillation or evaporation. If peroxides are detected, discard the chemical.	Store in a dark location and test for peroxide formation every 6 months after opening and before use. If peroxides are detected, discard the chemical.
Chemical Name	Butadiene* Chlorobutadiene (Chloroprene)* Divinyl acetylene Isopropyl ether Potassium amide Potassium metal Sodium amide Tetrafluoroethylene* Vinylidine chloride	Acetal Acetaldehyde Benzyl alcohol 2-Butanol Chlorofluoroethylene Cumene (isopropylbenzene) Cyclohexene Cyclooctene 2-Cyclohexene-1-ol Cyclopentene Decahydronapthaline Diacetylene (butadiyne) Dicyclopentadiene Diethylene glycol dimethyl ether Diethyl ether Dioxane Ethylene glycol ether acetates	Furan 4-Heptanol 2-Hexanol Methyl acetylene 3-Methyl-1-Butanol Methyl cyclopentane Methyl-isobutyl ketone 4-Methyl-2-pentanol 2-Pentanol 4-Penten-1-ol 1-Phenylethanol 2-Phenylethanol Tetrahydrofuran Tetrahydronapthelene Vinyl ethers Other secondary alcohols Isopropanol	Acrylic acid Butadiene** Chloroprene** Chlorotrifluoroethylene Ethyl acrylate Methyl methacrylate Styrene Tetrafluoroethylene** Vinyl acetylene Vinyl acetate Vinyl chloride Vinyldiene chloride Vinyl pyridine

* When stored as a liquid monomer

** When stored as a gas

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