Hand Protection and Glove Selection

Including Glove Selection for Some Specific Chemicals

Tom Shelley, Cornell EH&S

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Introduction

Glove selection is difficult for many lab staff. Different references seem to give conflicting information and the many available styles and types of glove materials add another layer of confusion. The process of glove selection can also be very time consuming. Consequently, many chemical users select a glove that may not be appropriate for the chemicals in use.

Due to the publicity surrounding the death of a prominent Dartmouth researcher, **Federal OSHA** has placed a strong emphasis on hand protection in the workplace, especially in academic and R&D labs. In 1994 OSHA made substantial changes to the PPE Standard, 29 CFR 1910.138 - Hand Protection. The revised requirements are as follows:

Hazard assessment and equipment selection
Employee training
Record keeping requirements
Guidelines for selecting PPE, and
Hazard assessment certification

Cornell EH&S Occupational Health and Safety Section has developed a revised written *Personal Protective Equipment Program* reflecting the changes in the OSHA standard.

Supervisors are responsible for the selection, availability and use of gloves and other personal protective equipment in the workplace. Geneva EH&S can assist supervisors with the requirements of the revised OSHA standard. Please contact us at X 2350 for additional information.

The various glove manufacturers use different formulations for their polymers. A glove from one firm may not have the same chemical resistance as a glove that appears to be an identical glove made by another firm. Therefore, it is prudent to check the **glove selection charts** provided by the glove manufacturer for the gloves you use to determine their suitability for use with any particular chemical.

However, glove selection based on the manufacturers' glove selection charts is often impossible, as only a limited range of chemicals have been tested for use with a specific manufacturer's glove. Many research grade chemicals are used in such small quantities that the various glove manufacturers will probably never test them. If a chemical is not listed on a glove selection chart it is advisable to have a specialist in **personal protective equipment (PPE)** make the glove selection for you. In this case the PPE specialist would attempt to match the known characteristics of the chemical to be used with the known characteristics of the polymers commonly used to make gloves to select a glove that would be appropriate. This glove selection document includes a compilation of gloves recommended by EH&S for specific chemicals.

In some cases it may be required to hire a **testing laboratory** specializing in PPE to physically test a variety of gloves with the chemical to be used to scientifically select an appropriate glove. We have contacted a local testing firm that is capable of testing gloves for chemical resistance for a modest fee. If you have an especially hazardous chemical for which glove selection is difficult, we can make arrangements to have various gloves tested with the chemical in question.

The glove selection for the materials listed below is offered for anyone using these chemicals at Cornell. If a particular manufacturer's glove charts vary from the glove selections below, *follow the manufacturer's glove charts* for the model of glove recommended or contact EH&S at X 2350 for a second opinion on glove selection for the chemical in use. The **Cornell Distribution Center** carries an assortment of 4 mil and 8 mil disposable nitrile gloves. They also carry or can order for you a wide variety of other types of gloves.

Latex gloves, especially thin, disposable exam gloves, are widely used in labs, shops and many other work environments. Our concern is two-fold: latex gloves offer little protection from commonly used chemicals and many people, up to 20% of the population by some estimates, have developed the allergen to latex products.

The use of latex gloves is *only* appropriate for:

most biological materials
nonhazardous chemicals
very dilute, aqueous solutions of hazardous chemicals*
clean work area requirements
medical or veterinary applications

*Less than 1% for most hazardous chemicals or less than 0.1% if a known or suspect human carcinogen is in use in aqueous solution.

Latex gloves offer no protection against many common lab and shop chemicals. They will severely degrade, often in a matter of seconds or minutes, when used with some materials.

Staff required to wear latex gloves should receive training on the potential health effects related to latex. Hypoallergenic, non-powdered gloves should be used when possible. If a good substitute glove material is available, use gloves made of a material other than latex. A general-purpose substitute for latex products is lightweight nitrile gloves.

Many of the recommendations below are for "**incidental contact**." This means that, as with many chemical procedures, no or very little actual contact with a chemical in use is anticipated. The gloves specified are basically there to prevent chemical contact with the skin when something goes wrong--a spill or splash to the hand, over spray from a dispensing device, etc. As soon as practical after the chemical makes contact with the gloved hand the gloves are removed and replaced. Often a glove specified for incidental contact is not suitable for **extended contact**, when the gloved hands may come into substantial contact with or actually may become covered with or immersed in the chemical in use. Generally speaking, a more substantial glove is required for extended contact than for incidental contact, although there are exceptions.

The practice of **double gloving** is recommended for many materials listed below. Two pairs of gloves are worn, one over the other. This affords a double layer of protection. If the outer glove starts to degrade or tears open, the inner glove continues to offer protection until the gloves are removed and replaced. The best practice is to check the outer glove frequently, watching for signs of degradation (change of color, change of texture, etc.). With the first sign of degradation remove the outer glove and reglove.

There are **different approaches to double gloving**. The most common practice is to wear a thin disposable glove (4 mil nitrile) under a heavier glove (8 mil nitrile). The outer glove is the primary protective barrier while the under glove retains dexterity and acts a vapor barrier in the event of mechanical failure or the permeation of the chemical in use through the outer glove. Alternately, you can wear the heavier (and usually more expensive and durable) nitrile glove as the under glove and wear thinner disposable nitrile gloves over those, changing the thinner outer gloves frequently. It is sometimes desirable to double glove with two sets of gloves made from different materials. Here, in the event of the failure of one material, the second, different material will act as a protective barrier until the gloves can be removed. The technique of using gloves of different materials is often advisable when a mixture of hazardous materials is in use. One type of material gives protection against one component or class of chemicals in the mixture and the second glove material gives protection against other components of the mixture. The requirements for double gloving and the materials of the gloves selected are specific to the chemical(s) in use.

For those materials that are rated **"supertoxic"**, which are easily absorbed through the skin, the glove material generally recommended is **Norfoil** (Silver Shield by North Hand Protection, 4H by Safety4, or New Barrier™ brand by Ansell Edmont). Norfoil is a thin, five-layer laminate with each layer made of a different polymer. They are chemically resistant to a wide range of materials that readily attack other glove materials. (Note that one of the common lab chemicals for which they are not recommended is chloroform.) Norfoil gloves look odd, like they were stamped out of a common garbage bag. They tend to be somewhat bulky but dexterity is regained by using a heavier weight (8 mil) disposable nitrile glove over the Norfoil glove. These gloves and others are also available at the Cornell Distribution Center and from lab safety supply houses.

Definitions for terms used in glove selection charts, the materials of which gloves are made and those used to describe different characteristics of gloves are listed towards the end of this document.

References used in preparation of this document are listed at the end.

If there is a chemical for which you have a question concerning glove selection that is not on the following list, please use the ***Glove Selection Request Form*** to be found at the end of this document.

Glove Selection for Some Specific Chemicals in Use at Cornell University

For quick glove selection see the table on pages 11.16-18.

Acetic acid (glacial or concentrated solutions): nitrile gloves (incidental contact); neoprene or butyl rubber gloves are recommended if contact with acetic acid above 10% is probable for an extended period of time.

Acetic anhydride: double glove with heavier weight (8 mil) nitrile gloves (incidental contact). Acetic anhydride is very corrosive to human tissues (skin, eyes, mucus membranes) and a poison by inhalation. For handling larger quantities of pure material *only* heavier weight (.28-.33 mm) butyl rubber or neoprene gloves are recommended.

Acetone: heavier weight (8 mil) natural rubber (incidental contact); for extended contact with acetone the *only* recommended glove type is butyl rubber.

If you are cleaning parts with acetone, or have any other use of acetone where there is more than incidental contact, you *must* use butyl rubber gloves. Natural rubber gloves have about a 10 minute breakthrough time and are for incidental contact only. Nitrile gloves have a less than four minute breakthrough time and are *not recommended* for any use of acetone.

Acetonitrile: nitrile gloves or double glove with nitrile gloves (incidental contact)

For transfer of acetonitrile or for large scale use, *only* heavier weight butyl rubber or poplyvinyl acetate gloves are recommended. Acetonitrile permeates though disposable latex exam gloves in a matter of seconds and latex gloves should *never* be used to handle this material.

Acrylamide: nitrile gloves or double glove with nitrile gloves (incidental contact); butyl rubber gloves are recommended for extended contact (such as repackaging pure acrylamide into smaller containers)

Acrylamide is readily absorbed through unbroken skin. Acrylamide is a carcinogen, mutagen, teratogen and a potent neurotoxin with *no known antidote*, so adequate hand protection is essential when using this chemical. Note that once acrylamide solutions are polymerized the resulting gels are no longer hazardous and, assuming that they are not contaminated with other hazardous materials, they may be disposed of in the ordinary trash.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with acrylamide.

***bis*- Acrylamide:** nitrile gloves

Bis- Acrylamide (N,N'-dihydroxy-ethylene-*bis*- acrylamide) does not share the more extreme toxic characteristics of acrylamide. However, its toxicological properties have not been fully investigated and it should be treated as a hazardous material.

Ammonium hydroxide: nitrile gloves; for extended contact heavier weight neoprene or butyl rubber gloves are superior to nitrile gloves

Benzotriazole, 1,2,3-: nitrile gloves

Carbon disulfide: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to carbon disulfide*

Most nitrile gloves have a breakthrough time of only 8 to 20 minutes and thus offer little protection when exposed to carbon disulfide. For operations involving the use of larger amounts of carbon disulfide,

when transferring carbon disulfide from one container to another or for other potentially extended contact, the *only* gloves recommended are viton and polyvinyl acetate (PVA).

Carbon tetrachloride: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to carbon tetrachloride*

Most nitrile gloves have a breakthrough time of only a few minutes and thus offer little protection when exposed to carbon tetrachloride. For operations involving the use of larger amounts of carbon tetrachloride, when transferring carbon tetrachloride from one container to another or for other potentially extended contact, the *only* gloves recommended are viton. Viton gloves are expensive, but they are the standard glove to use with carbon tetrachloride.

Carbon tetrachloride is a poison, carcinogen, mutagen and teratogen. It is readily absorbed through unbroken skin. Alcohol and acetone are known to enhance the toxicity of carbon tetrachloride. The dose required to cause poisoning in humans varies significantly, with the ingestion of as little as 2 ml. having caused death. Carbon tetrachloride is also a substantial ozone depleting chemical and its use has been banned commercially. If you can find a substitute for carbon tetrachloride, it is strongly recommended that you use an alternative material.

Catechol: nitrile gloves

Chloroform: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to chloroform*

Thin (3-4 mil) Nitrile gloves have a 4 minute breakthrough time and thus offer little protection when exposed to chloroform. For operations involving the use of larger amounts of chloroform, such as transferring chloroform from one container to another or for large-scale extractions, etc., the *only* gloves recommended are viton or polyvinyl acetate (PVA). Viton gloves are expensive, but they are the standard glove to use with chloroform.

Cobalt Chloride: See Heavy Metal Salts**.**

Copper (Cupric) Sulfate: nitrile gloves

3,3'-Diaminobenzidine (DAB): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with DBA.

Diazomethane in Ether (a derivatizing reagent): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to diazomethane in ether.*

For possible extended contact, such as when transferring diazomethane in ether or when making reagent solutions containing this material, the *only* recommended glove would be a Norfoil glove, due to the extreme hazards associated with this material. Diazomethane is an extreme poison, a cancer suspect

agent, extremely flammable, easily detonated and has an autoignition temperature of 100° C. (an ordinary light bulb would cause a sufficient quantity of the vapor in air to autodetonate). This is easily one of the most dangerous materials in use in labs at Cornell. If there is any way you can substitute another material for diazomethane in ether it is strongly recommended that you do so.

Dichloromethane: See Methylene Chloride.

Diethyl pyrocarbonate: nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Dimethyl sulfoxide (DMSO): heavier weight natural rubber gloves (15-18 mil; *not* 4 mil latex exam gloves) (incidental contact); butyl rubber gloves are recommended for extended contact; if you are allergic to natural latex products you may double glove with heavier weight (8 mil) disposable nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to DMSO.*

Nitrile gloves are *not* recommended for use with DMSO if extended contact with the hands is expected. Some brands of nitrile gloves have degradation times of five minutes when used with DMSO. DMSO freely penetrates the skin and may carry dissolved chemicals with it into the body, so hand protection is especially important if you are working with any hazardous materials dissolved in DMSO.

1,4-Dioxane (dioxane): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to dioxane*

Most nitrile gloves have a breakthrough time of only a few minutes and thus offer little protection when exposed to dioxane. For operations involving the use of larger amounts of dioxane, when transferring dioxane from one container to another or for other potentially extended contact, the *only* gloves recommended are butyl rubber gloves. Dioxane is one of the few commonly used lab chemicals that readily degrades viton gloves.

Dioxane is only moderately toxic, but it is a listed carcinogen, mutagen and teratogen. It is readily absorbed through unbroken skin so hand protection is especially important when working with this material.

Dithiothreitol (Cleland's Reagent): nitrile gloves

Ethanol: nitrile gloves

Ethidium bromide (EtBr): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with EtBr

Ethyl Ether (diethyl ether, ether)**:** double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to ether*

Ether is one of those chemicals that attacks almost all known commonly used glove materials. It permeates through viton, butyl rubber, neoprene, nitrile and natural rubber in a matter of minutes. The ***only*** recommended glove material for extended contact is polyvinyl acetate (PVA), such as the PVA™ brand made by Ansell Edmont.

Formaldehyde: nitrile gloves

Formamide: nitrile gloves (incidental contact); butyl rubber gloves are the *only* gloves recommended for direct contact with the pure material.

Formamide is often used in the pure form. If you use pure formamide in a procedure where there is probable contact with the skin, it is *strongly recommended* that you wear butyl rubber gloves.

Formic acid: double glove with heavier weight (8 mil) nitrile gloves (incidental contact)

Formic acid is very corrosive to human tissues (skin, eyes, mucus membranes). For handling larger quantities of pure material *only* heavier weight (.28-.33 mm) butyl rubber or neoprene gloves are recommended.

Gallic acid: nitrile gloves

Heavy Metal Salts (especially those that are easily soluble in water): nitrile gloves or double glove in some cases*****

For most *inorganic* (ionic) salts of heavy metals the human skin is usually an effective barrier against absorption of the heavy metal ions. If there are cracks in the skin, areas of inflammation, insect bites, cuts or other breaches of the integrity of the skin, heavy metal ions may be passed directly through the skin. The salts of many heavy metals are toxic or highly toxic and rated as poisons: **arsenic, bismuth, cadmium, chromium, cobalt, lead, mercury, nickel, osmium, silver and uranium**. Some of these materials are also listed as corrosives (chromium trioxide), inhalation hazards (osmium tetroxide), known or suspect carcinogens and mutagens (lead and lead salts, mercury and its salts, etc.) or radioactive (uranium). Disposable nitrile gloves are generally acceptable for the use of the pure salts and stock (concentrated) or dilute solutions for the common salts of the above metals (acetates, chlorides, sulfates, nitrates, anhydrides, oxides, hydroxides, etc.) *where only incidental contact* will be made with these materials or their solutions.

Several heavy metal salts are more easily absorbed by the skin than others. **Osmium tetroxide** is readily absorbed by the skin and is very toxic. **Lead acetate** is absorbed 1-1/2 times more easily than other lead salts. **Mercuric chloride** can be absorbed fairly easily, especially if there are cracks, cuts or other breaks in the skin. It is also very toxic. It is re**c**ommended to *****double glove***** with nitrile gloves when using these materials, especially when handing the pure compounds or their strong solutions.

It is important that used gloves, and other dry materials, contaminated with heavy metals are ***not*** disposed of in the ordinary trash. Place all heavy metal contaminated gloves in a separate waste stream (container). The College of Veterinary Medicine maintains a Medical Waste Program. Gloves (and other dry waste items) contaminated with trace amounts of heavy metals may be sent to the Vet College

for disposal. EH&S can furnish the guidelines provided by the Vet College or you may contact Dr. Larry Thompson at X 8-3-3966 or Denver Metzler at X 8-3-3288 for information on this program. It is important that the materials being disposed of are clearly identified on the Medical Waste Tracking Tag you will be required to complete as part of the disposal process, such as "Trace contaminated with lead acetate." (Note that this method of disposal is also acceptable for trace contaminated gloves and other dry waste generated from the use of carcinogens, mutagens and other materials that can not be disposed of in the ordinary trash.) Uncontaminated or decontaminated gloves may be disposed of as ordinary trash.

Heptane: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

For extended contact, as when using heptane for large scale extractions, refilling secondary containers or as a cleaning fluid, a heavier weight nitrile (35 mils or thicker), viton or PVA gloves are recommended. Note that the permeation time for heptane through 4 mil nitrile gloves is about 8 minutes and through latex exam gloves is even less time; subsequently, these gloves are *not recommended* for use with heptane.

Hexamethylenediamine (1,6-diaminohexane): heavier weight (8 mil) nitrile gloves (incidental contact); use a heavier weight neoprene glove when handling the pure material or concentrated stock solutions (extended contact)

Hexane: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

For extended contact, as when using hexane for large scale extractions, refilling secondary containers or as a cleaning fluid, a heavier weight nitrile (35 mils or thicker), viton or PVA gloves are recommended. Note that the permeation time for hexane through 4 mil nitrile gloves is about 12 minutes and through latex exam gloves is only about 5-6 minutes; subsequently, these gloves are *not recommended* for use with hexane.

Hydrochloric Acid (concentrated and strong solutions): nitrile gloves (incidental contact)

A heavier weight neoprene or butyl rubber glove would be superior for long-term use with more concentrated solutions, such as cleaning glassware that has been soaking in an HCl bath or other larger-scale use of HCl.

Hydrofluoric acid (HF): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

Note that additional protective equipment must always be worn when using larger quantities of HF. Nitrile or rubber sleeves, rubber aprons, face shields and splash goggles (*not* safety glasses) should also be worn. All users of HF must maintain an HF first aid kit in their lab. HF users are advised to contact EH&S for an “HF Users Information Packet.”

Isopropanol: nitrile gloves

Lead Acetate: See Heavy Metal Salts**.**

Laser dyes: nitrile gloves
Mecuric Chloride: See Heavy Metal Salts**.**

Mercury: nitrile gloves

Methanol (methyl alcohol): nitrile gloves

Methanol should never be allowed to make contact with the skin, as it is fairly easily absorbed by the skin. Methanol is a poison.

Methylene Chloride: double glove with heavier weight (8 mil) nitrile gloves (incidental contact)

Methylene chloride will permeate through thin (3-4 mil) nitrile gloves in four minutes or less. If you are double gloved, as recommended, and you splash or spill methylene chloride on your gloves, stop what you are doing and change the outer glove *immediately*. If you allow methylene chloride to remain on the outer nitrile glove for more than two to four minutes you must discard both sets of gloves and re-double glove. Methylene chloride permeates disposable latex exam gloves in a matter of seconds and latex gloves should *never* be used to handle this material.

For use of methylene chloride where contact with the glove is anticipated, such as stripping paint or gluing plastics, *only* polyvinyl acetate (PVA) or viton gloves are recommended. These gloves come in .28-.33 mm thickness. PVA offers the best protection.
Methyl sulfonic acid, ethyl ester (EMS) (ethyl methanesulfonate): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with EMS.
Monoethanolamine: nitrile gloves

Nickel chloride: See Heavy Metal Salts**.**

N-Methylethanolamine: : double glove with heavier weight (8 mil) nitrile gloves (incidental contact); *remove outer glove at once if exposed to N-methylethanolamine*

Viton, neoprene or butyl rubber gloves are recommended for extensive use of N-methyl-ethanolamine such as working with the pure material or making solutions.

Organophosphorous compounds: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

Osmium Tetroxide: See Heavy Metal Salts**.**

Paraformaldehyde: nitrile gloves

Petroleum ether: nitrile gloves (incidental contact); or heavy weight nitrile or viton for extended contact.

Phenol: double glove with heavier weight (8 mil) nitrile gloves (incidental contact); neoprene or butyl rubber gloves are recommended for extensive use of phenol such as working with the pure material or making solutions.

Nitrile gloves have a 30-minute breakthrough time with phenol. If working with double gloved nitrile gloves, change the outer glove frequently if exposed to this material.

Phenol-chloroform mixtures: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to mixture.*

Viton gloves are recommended for work with phenol-chloroform mixtures when probable exposure to the mixtures exists, such as when making up the mixtures. See the entries for phenol and chloroform.

Phenylmethylsulfonyl fluoride (PMSF): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions.

Phenylmethylsulfonyl fluoride is corrosive (causes burns) on contact with the skin, eyes and mucus membranes. It is also a highly toxic cholinesterase inhibitor and central nervous system poison. Avoid all contact.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with PMSF.

Polychlorinated biphenyls (PCBs): For weighing out of pure or concentrated materials, wear an 8 mil or heavier nitrile glove over a neoprene glove. For dilute solutions in corn oil (1 p.p.m. or less) neoprene gloves (20 mil) are recommended.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with PCBs.
Polyoxyethylenesorbitan monolaurate (Tween 20): nitrile gloves

Psoralen: nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Psoralen is corrosive (causes burns) on contact with the skin, eyes and mucus membranes. It is anticipated to be a carcinogen, it is a mutagen and a strong photosensitizer. Avoid all contact.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with psoralen

Pump oil: butyl rubber gloves

If you are changing pump oil or servicing pumps where contact with the oil may occur, the *only* recommended glove type is butyl rubber.

Silane based silanization or drivatization compounds: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if signs of degradation occur.*

Silver nitrate: See Heavy Metal Salts**.**

Sodium dodecyl sulfate (SDS): nitrile gloves

Sodium azide: nitrile gloves or double glove with nitrile gloves (incidental contact)

Sulfuric acid: heavier weight (8 mil) nitrile gloves (incidental contact); heavier weight (20 mil or greater) neoprene or butyl rubbber gloves (extended contact)

Tetrahydrofuran (THF): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if THF contacts glove*

For extended contact, such as when using THF for larger scale reactions, refilling secondary containers or as a cleaning fluid, *only* Norfoil gloves are recommended. Polyvinyl acetate (PVA) gives some limited protection (up to 1-1/2 hours for some gloves) but are inferior to the Norfoil gloves. Note that the permeation time for THF through 4 mil nitrile gloves and latex exam gloves is almost instantaneous; subsequently, these gloves are *not recommended* for use with THF.

3,3',5,5'-Tetramethylbenzidine (TMB): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with TMB.
N, N, N', N'-Tetramethylethylenediamine (TEMED): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions.

TEMED is corrosive (causes burns) on contact with the skin, eyes and mucus membranes.
Toluene: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to toluen.*

For extended contact, such as when using toluene for larger scale reactions, refilling secondary containers or as a cleaning fluid, *only* viton or polyvinyl acetate (PVA) gloves are recommended. Note that the permeation time for toluene through 4 mil nitrile gloves is less than 4 minutes and through latex exam gloves is less than that; subsequently, these gloves are *not recommended* for use with toluene.

Trichloromethyl chloroformate (diphosgene): This chemical, usually supplied in sealed glass ampules, is *very* air/moisture reactive, a corrosive and it is considered to be highly toxic by all routes of exposure. It must be used in a vented glove box or environmental chamber under dry nitrogen or argon. Glove boxes are usually fitted with substantial butyl rubber gloves, however, one manufacturer recommends that "heavy" gloves be worn over the glove box gloves. I would recommend using 8 mil or heavier nitrile gloves over the butyl rubber glove box gloves. *Please contact EH&S if you have any questions concerning the special procedures required for the use of this chemical.*

Triton-X100: nitrile gloves

Xylene: nitrile gloves (incidental contact)

For use of xylene where contact with the glove is anticipated, such as pouring of new or used xylene into containers or other operations, polyvinyl acetate (PVA) or viton gloves are recommended.

Definitions

Breakthrough is the time elapsed between the initial contact with a chemical and its detection inside a glove. Breakthrough time is directly proportional to glove material thickness for most materials.

Butyl rubber is a synthetic rubber (butylene and isoprene copolymer) that provides the highest permeation resistance to gases and water vapor of any protective material used to make gloves. Butyl rubber is an excellent choice for protection against esters and ketones, especially for extended contact with acetone.

Degradation is a change in one or more of the physical properties of a glove due to chemical contact. Some of these changes, such as discoloring, swelling, shrinkage or stiffness, may be visually detected but others are invisible. Degradation almost always results in a loss of performance of a glove and is an indicator of how long a glove will last. Degradation is usually detected by a change in weight of a glove and degradation ratings are often based on % change in weight over time.

Double gloving (see introduction, above) is the use of two layers of gloves to provide improved hand protection when using certain hazardous chemicals. This affords a double layer of protection. If the outer glove starts to degrade or tears open, the inner glove continues to offer protection until the gloves are removed and replaced.

Gauge or thickness of gloves is generally measured in mils. Higher gauge (thicker) gloves generally offer more protection. Generally speaking, doubling the thickness halves the permeation rate.

Finish refers to the surface texture of a glove material. Most laboratory gloves have a smooth finish. Textured surfaces are added to glove materials to provide a better grip on objects being handled.

Flock lining is a natural or synthetic shredded fiber that covers the inside of a glove to provide comfort by absorbing perspiration and providing ease in putting on and removing the glove.

Hypalon is a synthetic polymer that offers superior resistance to oxidizing agents and ozone. It is frequently used for glove box gloves.

Lower detection limit (LDL) is the minimum level detected with analytical test equipment, measured in parts per million (ppm) detected at breakthrough time.

Mil is the standard unit for measuring the gauge or thickness of glove materials. A mil is one-thousandth of an inch or 0.001". A millimeter is 39.37 mils; a mil is .00254 mm.

Natural rubber (or latex), produced from the sap of certain species of tropical trees, is used to make gloves that are suitable for the handling of biological materials, human blood and other body fluids, electronics assembly, food service and other applications where the *work* needs to be kept clean. Latex gloves are generally not suitable for use with most laboratory chemicals (see introduction, above). Latex products are also a health concern because of their protein component, to which many people are allergic. Natural rubber is often blended with other polymers to achieve various characteristics of those materials.

Neoprene is a synthetic rubber that is especially resistant to oils and petroleum products. It is also good for corrosives, alcohols, and many solvents. Neoprene is probably the best substitute material for the replacement of latex gloves for janitorial services, shop workers,
mechanics and other trades.

Nitrile, also referred to as NBR or acrylonitrile-butadiene, offers superior chemical resistance as well as puncture and abrasion resistance. 4 and 8 mil nitrile gloves are most often specified for general lab use for handling a wide variety of chemicals.

Norfoil (see introduction, above) is a lightweight, flexible laminate of several layers of polymers which offers superior resistance to permeation by a wide range of hazardous materials which often quickly degrade other glove materials. They are often used as an underglove with a tighter fitting glove of another material as an overglove to restore dexterity. Brand names of Norfoil gloves are Silver Shield by North Hand Protection, 4H by Safety4, and New Barrier™ brand by Ansell Edmont.
Overglove is a glove worn over another glove (underglove) when double gloving to provide multiple layers of resistance to hazardous chemicals. The overglove protects the underglove from chemical degradation and permeation. It is changed out when it begins to be chemically attacked to protect the underglove.
Penetration is the nonchemical transport of a chemical through a glove, usually by pinholes or microscopic tears or cracks resulting from degradation.

Permeation is the process by which a chemical passes through a glove's protective film. Permeation occurs at the molecular level and often leaves the appearance of the glove unchanged. The *rate of permeation* of a chemical through a glove is one of the determining factors in the effectiveness of a glove for use with a particular chemical. Generally speaking, the permeation rate is inversely proportional to thickness (gauge), although the length of time of exposure and temperature can be important factors for some glove materials. Permeation is an indicator of how long gloves are safe to wear.

Permeation rate at steady state is the maximum rate at which a chemical passes through a glove material, usually expressed in milligrams per square meter per second (mg./m.^{2}/sec.).

Permeation breakthrough is the time in minutes it takes for a chemical to permeate through a glove. Generally speaking, doubling the thickness of a glove quadruples breakthrough time.

Polyvinyl alcohol, or PVA, gloves give superior service for handling solvents, such as chloroform, that attack most other glove materials. PVA is water soluble and may not be used with *any* water-based materials.

Powdered gloves have an interior coating of cornstarch or other absorbent material. Powdered gloves are usually easier to take on and off and are often more comfortable for the wearer, but the powder may contribute to allergic responses in some individuals.

Supported means that the polymer of the glove is a coating over a fabric liner. This two- component glove style offers more durable hand protection. Very few gloves for laboratory use are supported.

Underglove is a glove worn under another glove (overglove) when double gloving to provide multiple layers of resistance to hazardous chemicals.

Unsupported means that a glove is made only of a pure polymer or mix of polymers. Unsupported gloves tend to offer greater dexterity and tactile sensitivity but less protection from physical damage.

Vinyl or polyvinyl chloride (PVC) gloves are economical substitutes for latex gloves for food service or assembly work but they are not resistant to many common laboratory chemicals and are not recommended for general laboratory work.

Viton is a very chemically resistant fluoroelastomer synthetic rubber. It protects against PCBs, benzene, aniline and most chlorinated and aromatic solvents. For some chemicals, such as chloroform, it is the only resistant material commonly available. Viton gloves are expensive, but they have a very long lifespan.

References Used

Ansell Edmont, *Chemical Resistance Guide,* 1990. For gloves made by this firm.

Best, *Guide to Chemical-Resistant Best Gloves,* 1997. For gloves made by this firm.

Cole-Parmer, '97-'98 *Catalog,* pp.1366-1372. This is a very generic, but useful, materials compatibility chart.

Fisher Safety, Sept., 1996, *Safety Products Reference Manual,* p. 223, 225 and 227. These charts are specific to gloves sold by Fisher. There is also a good overview of glove selection on pp. 220-222 of this catalog.

Lab Safety Supply, Aug., 1997 *General Catalog,* pp.99. This chart is specific to gloves sold by Lab Safety Supply.

Material Safety Data Sheets, from both manufacturers' and MDL-OHS data base at EH&S.
Merk Index, 10th Edition, 1983.

National Toxicology Program (NTP) chemical information sheets (available at EH&S). These information sheets are very well written and give information on specific gloves selected by NTP.

NIOSH, *Registry of Toxic Effects of Chemical Substances,* 1981-2.

Pioneer Industrial Products, *Chemical Resistance Guide,* no date. For gloves made by this firm.

Safety 4 A/S, *4H Chemical Protection Guide,* Sept. 1995. A chart for 4H brand gloves.

VWR Scientific Products, '97-'98 *Catalog,* p. 788-9. This chart is applicable only to Best gloves sold by VWR.

Electronic Resources

For those of you with Windows-based computers, Best has an electronic version of their glove selection chart available on their Web site at:

http://www.bestglove.com

You can download the software and install it on your PC. It does not have a Mac version.

---------- Cut Here ----------

Glove Selection Request Form

Name of chemical(s) _____
Please give the full name. Abbreviations may be difficult to find in the literature.

How is this chemical(s) being used? _____

How much is being used during a procedure? _____

Do you anticipate that the chemical may/will be in contact with the gloves? _____

Explain if possible. _____

Your name _____

Building _____ Room No. _____ Dept. _____

E-mail address _____ Phone No. _____

---------- Cut Here ----------

Copy and paste this form into an e-mail addressed to tjs1@cornell.edu. Please give your e-mail a subject, such as "Glove Selection Request."

Cornell University Chemical Hygiene Plan

Glove Selection Guide

Chemical	Incidental Contact	Extended Contact
Acetic Acid	nitrile	neoprene, butyl rubber
Acetic Anhydride	nitrile (8 mil), double glove	butyl rubber, neoprene
Acetone	natural rubber (latex) (8 mil)	butyl rubber
Acetonitrile	nitrile	butyl rubber, polyvinyl acetate (PVA)
Acrylamide	nitrile	butyl rubber
bis-Acrylamide	nitrile	
Ammonium Hydroxide	nitrile	neoprene, butyl rubber
Arsenic Salts	nitrile	
Benzotriazole, 1,2,3-	nitrile	
Bismuth Salts	nitrile	
Cadmium Salts	nitrile	
Carbon Disulfide	nitrile (8 mil), double glove	viton, polyvinyl acetate (PVA)
Carbon Tetrachloride	nitrile (8 mil), double glove	viton
Catechol	nitrile	
Chloroform	nitrile (8 mil), double glove	viton, polyvinyl acetate (PVA)
Chromium Salts	nitrile	
Cobalt Chloride	nitrile	
Cobalt Salts	nitrile	
Copper (Cupric) Sulfate	nitrile	
3,3'-Diaminobenzidine (DAB)	nitrile	nitrile, double glove
Diazomethane in Ether	nitrile (8 mil), double glove	Norfoil
Dichloromethane	nitrile (8 mil), double glove	polyvinyl acetate (PVA) or viton
Diethyl Pyrocarbonate	nitrile	nitrile, double glove
Dimethyl Sulfoxide (DMSO)	[1]natural rubber (latex)(15-18 mil)	butyl rubber
1,4-Dioxane	nitrile (8 mil), double glove	butyl rubber
Dithiothreitol	nitrile	
Ethanol	nitrile	
Ethidium Bromide (EtBr)	nitrile	nitrile, double glove
Ethyl Ether	nitrile (8 mil), double glove	polyvinyl acetate (PVA)
Formaldehyde	nitrile	
Formamide	nitrile	butyl rubber
Formic Acid	nitrile (8 mil), double glove	butyl rubber, neoprene (30 mils)
Gallic Acid	nitrile	
Heptane	nitrile (8 mil), double glove	nitrile (35 mil or thicker), viton, PVA

Hexamethylenediamine (1,6-Diaminohexane)	nitrile (8mil)	neoprene
Hexane	nitrile (8 mil), double glove	nitrile (35 mil or thicker), viton, PVA
Hydrochloric Acid	nitrile	neoprene, butyl rubber
Hydrofluoric Acid (HF)	nitrile (8 mil), double glove	
Isopropanol	nitrile	
Laser Dyes	nitrile	
Lead Acetate	nitrile, double glove	
Lead Salts	nitrile	
Mercuric Chloride	nitrile, double glove	
Mercury	nitrile	
Mercury Salts	nitrile	
Methanol	nitrile	
Methylene Chloride	nitrile (8 mil), double glove	polyvinyl acetate, viton
Methyl Sulfonic Acid, Ethyl Ester (EMS) (Ethyl Methanesulfonate)	nitrile	nitrile, double glove
Monoethanolamine	nitrile	
Nickel Chloride	nitrile	
Nickel Salts	nitrile	
N-Methylethanolamine	nitrile (8 mil), double glove	viton, neoprene, butyl rubber
Organophosphorous compounds	nitrile (8 mil), double glove	
Osmium Salts	nitrile	
Osmium Tetroxide	nitrile, double glove	
Paraformaldehyde	nitrile	
Phenol	nitrile (8 mil), double glove	neoprene, butyl rubber
Phenol-Chloroform mixtures	nitrile (8 mil), double glove	viton
Phenylmethylsulfonyl Fluoride (PMSF)	nitrile	nitrile, double glove
Polychlorinated Biphenyls (PCB's)	nitrile (8 mil) glove over a neoprene glove	neoprene (20 mil)
Polyoxyethylenesorbitan Monolaurate (Tween 20)	nitrile	
Psoralen	nitrile	nitrile, double glove
Pump Oil	butyl rubber	
Silane based silanization or derivatization compounds	nitrile (8 mil), double glove	
Silver Nitrate	nitrile	
Silver Salts	nitrile	
Sodium Dodecyl Sulfate (SDS)	nitrile	
Sodium Azide	nitrile	
Sulfuric Acid	nitrile (8 mil)	neoprene, butyl rubber (20 mil or greater)

Tetrahydrofuran (THF)	nitrile (8 mil), double glove	Norfoil
3,3',5,5'-Tetramethyl-Benzidine (TMB)	nitrile	nitrile, double glove
N,N,N',N'-Tetramethyl-ethylenediamine (TEMED)	nitrile	nitrile, double glove
Toluene	nitrile (8 mil), double glove	viton, polyvinyl acetate (PVA)
Trichloromethyl Chloroformate (diphosgene)	nitrile (8 mil) over butyl rubber glove box gloves	Material must be used in a glove box.
Triton-X 100	nitrile (8 mil), double glove	
Uranium Salts	nitrile	
Xylene	nitrile	polyvinyl acetate (PVA), viton

[1] If you are allergic to natural rubber products, you may double glove with 8 mil nitrile gloves.

Created 10/22/99 Tom Shelley