28 Protective Gloves

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28.1 Introduction

Gloves can protect the hands from chemical, biological, mechanical, thermal, and electrical hazards, which may occur in occupational settings, at home, and through hobbies, sports, and recreation. In addition to protecting the hands of the user, gloves also minimize pathogen or toxin exposure (e.g., between health care worker and patient or patient to patient) and protect products (e.g., circuit boards, food) from skin contact. When avoidance of a hazard(s) is not possible, proper use of personal protective equipment (PPE), including gloves, is essential. To be truly effective, any protective glove – its material, physical properties, and quality – must be suitable for its intended use and not create or exacerbate hand eczema.

28.2 Materials: Medical and Utility Gloves

The manufacture of rubber gloves – and, to a lesser extent, plastic, leather, and textile gloves – requires additives that remain in the glove in sufficient quantities to cause or exacerbate irritant or allergic reactions in some individuals. Consequently, individuals must understand the physical properties and antigenic nature of the glove choices, the prospective hazard(s), and their own allergy profile to select the appropriate glove.

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28.2.1 Rubber (Natural and Synthetic)

Rubber is made up of large molecules comprised of thousands of carbon atoms arranged in long stringlike chains in repeating sequences. Because of this molecular arrangement, rubber is classified as a polymer. The most common rubber polymers used today in glove manufacturing are isoprene, butadiene, chloroprene, and acrylonitrile. Rubber provides electrical resistance, gas impermeability, resistance to water and various chemicals, abrasion resistance, and elasticity, making it a good material for protective gloves. All rubber gloves (natural or synthetic) require vulcanization to cross-link the polymer chains and, therefore, require compounding with multiple chemicals known to cause irritant or allergic dermatitis.

28.2.1.1 Natural Rubber: Latex

Natural rubber latex (NRL) is a milklike liquid found in numerous plants, but primarily from the *Hevea brasiliensis* tree. It contains about 35 % natural polymeric rubber in the *cis* form of its 1,4-isoprene monomer. This rubber precursor molecule is synthesized within the cytoplasm of the laticifer cells of the tree and exists in the raw latex as long chains. NRL gloves are often the material of choice in medical and other occupational environments because of their exceptional flexibility, strength, elasticity, temperature resistance, and low cost. NRL resists abrasions from grinding and polishing and protects hands from most water-based solutions of acids, alkalis, salts, and ketones. NRL proteins have been reported to cause type I and type IV hypersensitivity. As with all rubber (natural or synthetic), type IV reactions to residual processing chemicals are possible and require user caution. NRL is susceptible to oxidation. The following steps are necessary to preserve the physical properties and shelf life of NRL gloves during storage: (1) maintain a temperature under 25°C, (2) provide a relative humidity low enough that condensation does not occur, and (3) protection from sunlight, fluorescent light, ionized radiation (x-ray equipment), and ozone (instrument asepsis, electrical equipment, air purification).

28.2.1.2 Synthetic Rubber: Nitrile

Nitrile or acrylonitrile butadiene rubber (NBR) is a synthetic alternative to NRL gloves. NBR provides users with good sensitivity and dexterity; however, NBR is less elastic than NRL [1]. Delivering good performance under heavy use, the material provides protection, even during prolonged exposure to substances that cause other gloves to deteriorate. NBR offers good resistance to chlorinated solvents, oils, greases, acids, caustics, and alcohols, although this resistance varies with the acrylonitrile content. NBR gives poor protection, however, against strong oxidizing agents, aromatic solvents, ketones, and acrylates. Generally, the material has good tensile strength and resistance to puncture; however, higher levels of strength require reinforcing agents. Although they provide good puncture resistance, NBR gloves are more prone to complete failure once a hole or tear is initiated. As with all rubbers, NBR must be vulcanized; therefore, delayed reactions to the processing chemicals may occur. Many NRL glove users switch to synthetic rubbers owing to concern about "latex allergy," only to find that they are really allergic to an accelerator or other chemical that is the same or similar to those in the NRL product. The synthetic rubbers do not, however, contain the NRL proteins; therefore, they are a good choice for those individuals with an NRL protein sensitivity.

Recent studies have compared the protective value of NBR, chloroprene, and barrier-laminate gloves and of NBR and NRL gloves against pesticides and have determined that the NBR gloves tested provided a higher level of protection [2]. Caution should be exercised when expanding this conclusion to include all NBR gloves in other chemical-exposure situations.

28.2.1.3 Synthetic Rubber: Chloroprene

Chloroprene (CR) (neoprene) is a synthetic rubber that is pliable, provides good dexterity, and is tear resistant [1]. CR has demonstrated resistance to hydraulic fluids, gasoline, alcohols, organic acids, alkalis, oils, and fats and may also provide enhanced chemical and wear resistance compared to natural or other synthetic rubbers in some situations. A 2003 study tested the permeability of seven brands of surgical gloves to seven chemicals commonly used in hospitals. The gloves offering the best protection were CR gloves and a thick, double-layered NRL glove with a polymeric hydrogel inner coating and an inner glove. The research indicated that permeation resistance depended on both the brand of glove and the chemical tested. CR is sometimes blended with NRL to improve resistance to oil, ozone, and weathering [3]. As with NBR, CR is a synthetic rubber and must be vulcanized. Delayed reactions to the processing chemicals are well documented.

28.2.2 Plastic

Vinyl or polyvinyl chloride (PVC) is an alternative to rubber gloves, especially in situations in which there is concern about NRL protein allergies. The material's low cost makes the gloves popular in some environments, such as in health care, food service, and cleaning. Thin, single-use PVC examination gloves offer poor resistance to solvents and chemical exposure and are intended for short-term wear. PVC gloves provide similar control and tactile sensitivity compared to rubber gloves; however, they do not have the same elastic qualities that impact fit and feel. Manufacturers can alter the modulus and stretch properties to create enhanced softness, flexibility, and elasticity with plasticizers. Some of these plasticizers contain phthalates that have been restricted in specific end uses owing to health and environmental concerns. Phthalate-free gloves are now available. Both irritant and allergic reactions have also been reported to occur with PVC gloves [4–6].

28.2.3 Other Polymers, Leathers, and Textiles

Manufacturers make protective gloves from a variety of other rubbers (Tables 28.1 and 28.2).

These materials all possess different strengths and weaknesses and may be options for some users and workplaces. When selecting any protective glove, it is essential that the hazard(s) be fully assessed.

28.2.3.1 Leather

Leather gloves are comfortable because the material breathes, absorbs humidity, is durable, permits dexterity, is resistant to heat, and gives mild abrasion protection. Manufacturers make leather from cowhide, pigskin, goatskin, deerskin, elkskin, and bison leather, all of which may be chromium or vegetable tanned. Chromium-tanned leather gloves can cause contact dermatitis [14]. Occlusive coverage of the hands fosters increased perspiration, which can increase release of chromium from the leather in sufficient amounts to induce contact allergy. The rubber underliner often used with leather gloves also can cause contact allergy. When individuals wear rubber gloves, they also often use *glove powder*, a cooling, frictionless powder that aids donning and absorbs moisture and perspiration. *Glove powder* is usually a talc that incorporates fragrance and preservatives and, therefore, may also be a source of contact irritant reactions.

28.2.3.2 Textiles

Manufacturers use many fibers in woven or knitted textile gloves – cotton, viscose, nylon, and polyester as well as Kevlar, Nomex, and carbon fiber. Textile gloves are pliable and cheaper than leather gloves and are machine washable. They can be partially or totally coated with rubber (NBR or butyl) or plastic materials to improve protection, grip, or dexterity. Totally coated gloves may be suitable for handling water and liquid chemicals. Potential users should check with the manufacturer to determine the gloves' effectiveness for use with specific chemicals or under specific environmental conditions.

28.2.3.3 Specialty Gloves

Manufacturers have developed specialized gloves, such as metal-mesh gloves, that typically consist of welded, nickel-plated brass, or stainless steel. Metal-mesh gloves have the potential to create problems in nickel-allergic users; however, some manufacturers wrap metal meshes in polyester and coat them with PVC.

Table 28.1 Synthetic rubber glove materials

Glove type	Pros	Cons
Butyl rubber (IIR) [1, 7]	Extreme resistance to moisture, oxidation, and corrosive chemicals	Difficult to manufacture, requiring more active accelerators during manufacture, including chemicals such as thiuram sulfides that can cause type IV allergic contact dermatitis
	Impermeability to gases	Not as resilient as NRL and other synthetics
	Enhanced thermal stability	Poor performance against aliphatic and aromatic hydrocarbons and halogenated solvents
	Resistance to abrasion	
	Flexibility at low temperatures	
	Protection against many chemicals, such as peroxide, rocket fuels, highly corrosive acids (nitric, sulfuric, and hydrofluoric acids and red-fuming nitric acid), strong bases, alcohols, aldehydes, ketones, esters, and nitro compounds	
Ethylene propylene rubber (copolymers [EPDM] or terpolymers [EPR]) [1, 8, 9]	Good tensile properties	Only fair resistance to aliphatic and aromatic hydrocarbons, such as mineral oils, gasoline, and fuels
	Good resistance to heat, low temperatures, oxidation, and ozone	Frequent combination with polyethylene, polypropylene, or other thermoplastic resins to make thermoplastic elastomers, causing varying degrees of heat and oil resistance and elasticity
	Resistance to electricity	
	Protection against chemicals and polar solvents, such as water, acids, alkalis, phosphate esters, and many ketones and alcohols	
Fluoro rubber (FPM) [10]	Very good resistance to heat and cold	Inflexibility at low temperatures
	Resistant to aging and ozone	Sensitivity to the effect of amines, organic acids, and polar solvents
	Low permeability to gas	
Chloroprene (CR) [1, 7, 11]	Resistant to chemicals, atmospheric degradation, oils, and fats, and tears	Numerous compounds with a broad range of physical properties
Neoprene, which DuPont developed in 1931, became the generic name for polymers of the monomer chloroprene	Good elastomeric properties, being pliable and providing finger dexterity	Expensive
	Protection against hydraulic fluids, gasoline, alcohols, organic acids, and alkalis	Poor tear propagation resistance
	Better chemical and wear resistance and a better grip than NRL	
	Manufacturers sometimes blend chloroprene with NRL to improve the product's resistance to oil, ozone, and weathering	
Nitrile or acrylonitrile butadiene rubber (NBR) [1, 7]	Good sensitivity and dexterity	Resistance to chemicals, oils, and body fat varies with the acrylonitrile content
	Good resistance to chemicals, oils, and body fat	Less elastic than NRL
	Good tensile strength	Necessity of reinforcing agents for high strength
	Protection against chlorinated solvents, such as trichloroethylene and perchloroethylene; oils; greases; acids; caustics; and alcohols	Poor protection against strong oxidizing agents, aromatic solvents, ketones, and acrylates
	Good performance under heavy use, even during prolonged exposure to substances that cause other gloves to deteriorate	Poor tear propagation resistance

Table 28.1 (continued)

Glove type	Pros	Cons
Polybutadiene rubber (BR) [1, 9]	Superior resistance to abrasion when blended with NRL or SBR	Relatively low gum tensile strength unless manufactured with reinforcing fillers (usually done)
	Resilience	
	Flexibility at low temperatures	
	Resistance to cracking due to its ozone resistance	
Polyisoprene rubber (IR) [1]	Qualities similar to NRL, without the sensitizing proteins	An expensive option
	Good tack, high tensile strength (depending on the compounding), and good hot tear properties	Poor aging
Silicone rubber (VMQ) [1, 10]	Little change when exposed to extreme temperatures	Sensitivity to hot water and steam
	Resistant to aging and ozone	Poor protection against fuels
	Good electrical insulation	
	Excellent protection against corrosion and solvents	
	Moderate protection against oil	
Thermoplastic elastomers (TPEs) [1]	High tensile strength	Dependency of a particular TPE's properties on the formulations and the solvents that the manufacturer uses
A class of copolymers or a physical mix of polymers, usually a plastic and a rubber	Superior to NRL in resistance to abrasion, cracking, and oxidation	Manufacture with solvents, causing poor resistance to similar solvents or chemicals
	Few ingredients compared with the numerous potentially allergenic chemicals that other rubbers contain	
	Manufacture without vulcanization with its use of antigenic materials	
Types of TPE		
Styrene-butadiene rubber (SBR) [1, 10]	Moderate tear strength	Use of dithiocarbamates, a sensitizer, as an anti-degradant, possibly causing type IV allergic contact dermatitis
	Better resistance to abrasion and aging than NRL	Staining for some SBRs in the presence of copper and other metals
		Low resistance to heat
		Fair to poor resistance to oils, greases, and fuels
Styrene-ethylene-butylene-styrene rubber (SEBS) [1]	Excellent resistance to aging and high temperatures	

28.3 Hazards

28.3.1 Chemical

The skin of the hands is an important route by which poisonous and carcinogenic chemicals can enter the body in amounts sufficient to evoke adverse effects. Researchers estimate that 70–75 % of all contact dermatitis and 80–95 % of occupational dermatitis will impair the worker's hands [15–17]. Although biological and physical causes contribute to the incidence of skin disease, chemical exposure is responsible for 80–90 % [18]. Examples of such chemicals found in the work environment include pesticides, herbicides, aromatic nitro and amino compounds, phenols, polyurethanes, hydrocarbons (*m*-xylene, polychlorinated biphenyls), epoxy resins, acrylates,

Table 28.2 Plastic glove materials

Glove type	Pros	Cons
Vinyl (polyvinyl chloride [PVC]) [1, 11]	Cost-effective alternative to rubber gloves, making the gloves popular in some environments, such as in food service and cleaning	Poor resistance to solvents and chemicals
	Similar control and sensitivity compared to rubber gloves	Use of a high proportion of plasticizing oils, some of which contain phthalates that regulators have restricted in specific end uses due to health and environmental concerns, to create softness, flexibility, and elasticity
	Rigidity or flexibility depending on the manufacturing process	Lower strength and protection than rubber gloves for the less expensive versions
Polyethylene (PE) [1, 12]	Flexibility	Lower elasticity
	Protection from organic vapors, dusts, and mists	Seams
	Good chemical resistance	Poor fit/poor dexterity
	Low extractables/particulates (lower particulate gloves are required in some clean room settings)	Stiff
		Poor electrical properties
Polyurethane (PU) [1, 11]	High toughness and elasticity	An expensive option
	Low levels of antigenic chemicals	Rigidity or extreme elasticity depending on the polymer used
	Resistance to tears and abrasion	
Polyvinyl alcohol (PVA) [13]	Good resistance to alcohol	Poor protection against water or water-based solutions being a water-soluble plastic used for dip-coating textile gloves
	Protection against methylene chloride, toluene, 1,1,1-trichloroethane, and trichloroethylene	

and organic and inorganic cyano compounds. These chemicals may have allergenic, irritant, toxic, or even teratogenic and carcinogenic effects [19–21]. Additionally, chemical substances, such as strong alkalis and acids, certain organic solvents, metal salts, and gases have the potential to cause chemical burns leading to ulcerations, even with minimal exposure [22] (Table 28.3).

Glove materials vary greatly in their resistance to chemicals, as do different formulations of the same glove material. For example, not all NRL gloves provide the same measure of barrier protection against the same chemicals [24]. The permeability of a glove's polymer to chemicals, and therefore the gloves protective capabilities, depends on many factors, including:

- Type and concentration of the chemical(s)
- Interaction with multiple chemicals
- Duration of exposure
- Interaction between chemical(s) and the glove's material
- Impact of simultaneous mechanical hazards
- Glove's base polymer
- Glove's formulation (plasticizers, fillers, stabilizers, pigments, degree of cross-linking)
- Glove's physical properties
- Barrier integrity (holes, defects, oxidation, etc.)

During exposure, a chemical's molecules can enter and migrate through the glove. This migration can occur with no visible change in the material, often leaving the user unaware that the chemical has permeated the glove [25]. This chemical migration can take place even if the glove has no pinholes, tears, or defects. Therefore, safe use requires an examination of the gloves breakthrough time, permeation rate, and degradation potential (Table 28.4).

28.3.1.1 Health Care Settings

In health care settings, acrylates, disinfectants, and cytotoxic drugs can permeate or degrade gloves. Examination gloves do not provide

Table 28.3 Glove materials available for chemical resistance[a]

Group of chemicals	Recommended glove material[b,c]
Aldehydes	Chloroprene rubber (CR), glutaraldehyde only Nitrile rubber (NBR), formaldehyde only Flouropropylene (FPM), formaldehyde and glutaraldehyde only
Aliphatic hydrocarbons	Nitrile rubber (NBR) Polyvinyl alcohol (PVA), cyclohexane excluded Flouropropylene (FPM)
Alkalis	Butyl rubber (IIR) Natural rubber latex (NRL), potassium hydroxide (up to 70 %) and sodium hydroxide (70+ %) only Chloroprene rubber (CR), potassium hydroxide (up to 70 %) and sodium hydroxide (70+ %) only Nitrile rubber (NBR) Polyvinyl chloride (PVC), potassium hydroxide (up to 70 %) and sodium hydroxide (70+ %) only Flouropropylene (FPM), potassium hydroxide (up to 70 %) only
Amines	Butyl rubber (IIR), butylamine and triethylamine excluded Chloroprene rubber (CR), ethanolamine only Nitrile rubber (NBR), aniline and ethylamine excluded Flouropropylene (FPM), aniline and ethylamine excluded
Aromatic hydrocarbons	Nitrile rubber (NBR), benzene, toluene, and xylene excluded Polyvinyl alcohol (PVA), ethyl benzene excluded Flouropropylene (FPM), benzene excluded
Esters/glycols	Butyl rubber (IIR), ethylene glycol, methyl acetate, and isobutyl acrylate only Flouropropylene (FPM), ethylene glycol only
Halogenated hydrocarbons	Butyl rubber (IIR), polychlorinated biphenyls (PCBs) only Chloroprene rubber (CR), polychlorinated biphenyls (PCBs) only Polyvinyl alcohol (PVA) Flouropropylene (FPM), methyl chloride and halothane excluded
Inorganic acids	Butyl rubber (IIR), chromic acid (up to 70 %), hydrochloric acid (up to 37 %), phosphoric acid (up to 70+ %), and sulfuric acid (up to 70+ %) only Natural rubber latex (NRL), perchloric acid (up to 70 %) and phosphoric acid (up to 70+ %) only Chloroprene rubber (CR), perchloric acid (up to 70 %) and phosphoric acid (up to 70+ %) only Nitrile rubber (NBR), perchloric acid (up to 70 %) and phosphoric acid (up to 70+ %) only Polyvinyl chloride (PVC), perchloric acid (up to 70 %) and phosphoric acid (up to 70+ %) only Flouropropylene (FPM), chromic acid (up to 70 %), nitric acid (up to 70+%), perchloric acid (up to 70 %), and phosphoric acid (up to 70+ %) only
Organic acids	Butyl rubber (IIR), maleic acid excluded Natural rubber latex (NRL), lactic acid and oxalic acid only Chloroprene rubber (CR), lactic acid and oxalic acid only Nitrile rubber (NBR), lactic acid and oxalic acid only Polyvinyl chloride (PVC), oxalic acid only

[a]This table provides general information regarding chemical groupings and potential choices of glove materials but does not represent specific selection criteria regarding the chemical resistance of a type of glove. Created with data from [12, 13, 23]
[b]The table includes recommendations reflecting the gloves that best fit the category for intended use. Those gloves and other gloves may meet requirements for use with other chemicals under certain conditions, such as use for less than 4 h
[c]Laminated plastic materials of folio type or Teflon are suitable for protection against most chemicals

Table 28.4 Chemical resistance criteria

Breakthrough time	Usually expressed in minutes, this rating indicates the time that it takes from the initial chemical exposure of the glove's surface to the first detection of the chemical on the other side of the glove's wall These times indicate how long a user can expect a glove to provide effective permeation resistance when totally immersed in the tested chemical [12, 26] The permeation rate evaluates the time it takes for a chemical to pass through the glove's (intact) material without going through pores or visible openings
Permeation rate	The permeation rate represents the highest *flow rate* recorded for a chemical with respect to its permeation of a glove's material during 6–8 h of testing [12] Many chemicals permeate gloves without visibly affecting the materials and thus gain access to the skin often unbeknownst to the user If a chemical permeates through the glove, it may cause adverse effects to the skin, or it can be absorbed through the skin and cause exposure effects elsewhere in the body [21] Even chemicals that are considered "harmless" can damage the skin if the exposure is frequent or prolonged. It is crucial to be aware that chemical permeation through disposable gloves can sometimes be efficient and rapid [27]
Degradation	This characteristic evaluates the change in a glove's physical properties with chemical contact The material may disintegrate or become stiff or brittle due to exposure to chemicals. Alternatively, the materials may become softer and weaker, expand to several times their initial size, and even melt or dissolve A change in the physical properties of a glove's material can quickly impair the glove's permeation resistance to microorganisms [28]

adequate protection against many cytotoxic drugs and are primarily intended to provide short-term protection from biological transmission, not chemical or mechanical hazards. A glove's thickness is also a consideration but is not the only factor in assessing a glove's protection capabilities.

Acrylates

Methyl methacrylate used in orthopedic surgery is the best-known chemical against which rubber surgical gloves fail to offer protection [29, 30]. In a 2000 in vitro study of five different brands/types of NBR and NRL gloves, Munksgaard found in general that NBR gloves protected against skin contamination from methacrylates longer than NRL gloves, in the absence of solvents. Dilution of the methacrylates in organic solvents reduced or removed that advantage [31]. A 2009 study compared and measured time for methyl methacrylate monomer (MMA) to permeate NRL, PVC examination gloves, and industrial CR gloves. Both NRL and PVC clinical gloves became permeable quickly. CR industrial gloves remained impervious for 25 min. Clinicians participating in the study were advised by the researchers of the toxic effects of MMA and the limitations of examination gloves as a chemical barrier [27].

Disinfectants

The use of disinfectants and sterilants is important in many occupational settings, and researchers have performed several chemical-permeation studies comparing multiple brands of single-use examination, surgical, and utility gloves [32–34]. These studies described permeation tests against glutaraldehyde, ethanol, isopropanol, chlorhexidine digluconate, hydrogen peroxide, peracetic acid, p-chloro-m-cresol, and formaldehyde and indicated varied results depending on the material, glove type (examination, surgical, utility), and testing methodology.

In 1992, Mellstrom et al. tested isopropanol, ethanol, p-chloro-m-cresol, and glutaraldehyde on the material structure and protective effect of NRL and PVC examination gloves and polyethylene utility gloves for 10, 30, and 60 min. Isopropanol permeated both NRL and PVC (<10 min.). Breakthrough times for the different brands of polyethylene varied and ranged from 4 to 240 min. Ethanol permeated NRL and PVC gloves at a much lower rate. The p-chloro-m-cresol and glutaraldehyde did not permeate any of the gloves within 60 min. Isopropanol had a destructive effect on both NRL and PVC [25]. In 2000, Connor and Xiang also studied the effect of isopropyl alcohol on the permeation of NRL and NBR gloves exposed to antineoplastic agents (cancer chemotherapy drugs, cytotoxic drugs), including carmustine, cyclophosphamide, fluorouracil, doxorubicin, thiotepa, and cisplatin. The researchers evaluated the gloves against the antineoplastic agents after exposing them to 70 % isopropyl alcohol for 0.5, 1, and 5 min. The researchers concluded that disinfecting with 70 % isopropyl alcohol did not affect the integrity of the NRL and NBR gloves [35].

Jordan et al. (1996) tested the permeability of six gloves with various glutaraldehyde formulations. The NBR (utility), butyl rubber (utility), styrene–butadiene-block polymer (surgical), and polyethylene(utility) gloves were each impermeable for at least 4 h to 2 % and 3.4 % glutaraldehyde. The two NRL examination gloves showed breakthrough at 45 min. When double-gloving with the NRL gloves, breakthrough time increased to 3–4 h. With 50 % glutaraldehyde, only the butyl- and NBR-rubber utility gloves were impermeable for extended periods. The surgical glove had breakthrough at 1 h, and the polyethylene and the two NRL examination gloves had breakthrough at less than 1 h [36].

In 2000, Monticello et al. evaluated six types of glove materials, comparing thickness measurements for resistance to permeation by a 7.5 % hydrogen peroxide. Both the PVC and NRL examination gloves at 4.5-mm thickness provided less than 30 min of protection, while the thicker NRL glove (16.5 mm) lasted for 8 h without any detectable penetration. CR (15 mm) and NBR butyl rubber (18 mm) gloves both provided protection throughout the 8 h test period [34].

Cytotoxic Drugs

Researchers have also shown that examination gloves do not provide adequate protection against many cytotoxic drugs; thus, they have examined surgical gloves and industrial gloves to identify which of these gloves acts as an adequate barrier to these agents. In 1984, Connor et al. tested the permeability of both single- and double-thickness NRL (surgical and utility) and PVC (utility-0.20 mm and 0.35 mm) gloves for 5–90 min. A double thickness of all gloves (especially the thicker PVC) reduced the amount of drug permeation. The researchers concluded that both single and double thickness of NRL and PVC gloves offered limited protection against carmustine. NRL surgical gloves were slightly less permeable [37]. Dolezalová et al. assessed the permeation of cisplatin, cyclophosphamide, doxorubicin, 5-fluorouracil, and paclitaxel through PVC, NRL, and NBR gloves. Their simulated, time-dependent permeation experiments showed that only the NBR gloves provided good protection [38]. In 1999, Singleton and Connor evaluated permeability of carmustine, etoposide, and paclitaxel in 13 brands of chemotherapy (thicker) gloves and one brand of examination glove. Of the 14 glove types tested, 11 were NRL, and three were NBR. All 14 gloves were impermeable to carmustine at 2 h. Only two (NRL chemotherapy) of the 14 gloves were impermeable to all three drugs. The remaining 12 gloves all demonstrated permeation within 2 h. Thirteen gloves tested for paclitaxel permeability were impermeable at 2 h [39].

28.3.1.2 Other Work Settings

Manufacturers use acrylates in production of glues, paints, lacquers, varnishes, printing inks, artificial nails, bone cement, insulin pump plates (glues), transcutaneous electrical nerve stimulators, disposable electrosurgical grounding plates (glues), spectacle frames, hearing aids, electron microscopy embedding medium, and many other products, resulting in sensitization of workers in many different fields [40, 41]. Other studies have examined the relationship between sensitization to particular chemicals and the use of gloves in other occupations, such as hairdressers [42], workers in swine slaughterhouses [43], cleaners [44], leather workers [45], and automechanics/machinists [46]. Owing to the complexity of selecting the appropriate gloves against chemical exposure, it is essential that these decisions be based on an understanding of the task involved, properties of the chemical(s), glove-material formulation, and the physical properties of the glove to ensure adequate protection (Table 28.5).

Table 28.5 Occupational exposure to chemicals commonly causing contact dermatitis

Occupation	Chemicals
Agricultural workers	Pesticides, weed killers, oils, solvents
Cleaners/janitorial workers	Solvents, detergents, cleaning agents, water
Construction workers	Epoxy resins, metals, cement, glues, paints, lacquers, varnishes
Cosmetologists/hairdressers	Water, shampoos, dyes, bleaching products, chemicals for permanents
Food service workers	Proteins in fruits, vegetables, and grains; water
Health care workers (medicine, dentistry, veterinary science)	Preservatives, disinfectants, topical medications, acrylates, metals, antineoplastics, water
Maintenance workers	Solvents, oils, paint, epoxy resins, degreasers, cement, tar
Mechanics/engineering	Metalworking fluids, oils, solvents, degreasers, adhesives, cement, etc.
Painters	Paints, solvents, primers
Printers/lithographers	Processing chemicals, inks, plate-cleaning solvents, adhesives

28.3.2 Biological

Biological hazards refer to organisms or the organic substances they produce that are detrimental to human health, including parasites, viruses, bacteria, fungi, and proteins. Contact with these microorganisms poses a risk of infection or allergic reaction. Although the skin offers natural protection against external threats, it is often inadequate, especially if a person has a compromised dermal barrier. Therefore, safe handling of biological materials requires protective gloves that minimize the risk of contamination and protect workers.

Individuals in many occupations come into contact with biological hazards, including workers in health care, agriculture, forestry, fishing, and food preparation. The list of biological causes of occupationally related dermatoses includes, but is not limited to, the following allergens:

- Animal-derived allergens (cow dander, wool fats, or alcohols)
- Enzymes (papain, fungal cellulase)
- Plants (poison ivy, oak, NRL, or Compositae)
- Woods
- Foods (shrimp, beef, garlic, mango)

28.3.3 Mechanical

Injuries from mechanical and physical hazards include damage from friction and pressure, impacts, cuts, lacerations, abrasions, burns, vibration, animal bites, and repetitive strain [47]. Often protective gloves must protect users not only from chemical and biological exposures but also against mechanical hazards including cuts, tears, needlesticks, and abrasion. In health care, single-use disposable gloves do not offer a high degree of protection against physical and mechanical hazards, and thicker utility gloves may be a better choice for certain tasks. The use of two pairs of gloves (double-gloving), underliners, and gloves impregnated with disinfectants are also strategies used to address these multiple hazards [48].

Leather comes in multiple styles and thicknesses with varied protective capabilities. For greater protection, users sometimes add disposable, chemically resistant, multilayered plastic gloves as inner gloves. Reinforcement of leather gloves using steel staples or studs improves their cut resistance.

Plastic and rubber coatings improve the cut resistance of textile gloves, also ensuring a slip-resistant grip. In some textile gloves, tough filaments, such as high-tenacity polymers or even fine steel wires, form part of the fabric's structure. Materials providing mechanical-hazard protection may include Kevlar (para-aramid fiber), NRL, NBR, or PVC on a fabric liner.

28.3.4 Thermal and Electrical

Both heat and cold can damage skin, and manufacturers make thermally protective gloves from aluminized leathers or fibers, Kevlar, leather, or cotton. Electrical hazards require specially designed insulating gloves that most often are rubber, and, generally, users wear glove liners against the skin to improve fit and decrease friction between the hand and the glove. Workers also often wear leather glove protectors over the rubber gloves to provide mechanical protection against cuts, abrasion, and punctures.

Conclusion

Chemical, biological, mechanical, thermal, and electrical hazards pose threats to individuals at home, in workplaces, and through hobbies, sports, or recreation. Gloves can provide protection against some threats, but their use also entails problems, including use of materials that can cause irritant or allergic contact dermatitis. Each glove user must consider the unique requirement of the environment and the hazard(s) as well as his or her health history, allergic profile, and dermal condition to ensure appropriate protection.

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