

Review Article

A review of the materials and allergens in protective gloves

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The ingredients previously reported to cause protective glove allergy are presented and evaluated for strength of evidence. Allergens that have caused both delayed hypersensitivity and contact urticaria are considered for rubber, plastic, leather, and textile gloves. The current guidelines regarding glove manufacture are described. A list of materials confirmed by the industry to be used in glove production is presented together with a suggested series for investigating patients with delayed type hypersensitivity and contact urticaria secondary to glove use.

Key words: allergic contact dermatitis; contact urticaria; rubber chemicals; occupational. © John Wiley & Sons A/S, 2009.

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Glove allergy poses a significant work burden in occupational medicine. In one centre, 5.6% of all patients undergoing patch testing were being investigated for suspected glove allergy (1). Health care professionals, cleaners, and hairdressers are the most frequently affected. Although gloves are worn to protect the skin from exposure to potential irritants and allergens and harmful biological agents, they may actually encourage penetration of certain chemicals by affecting the skin's natural barrier function (2). A current comprehensive review of allergens for commonly used glove types is not available. The aim of this article is to briefly review reported allergens for the different glove types and grade the level of evidence, list ingredients that the industry has confirmed are being used in the manufacturing process, and to propose a 'glove series' for future use. For each glove type, both delayed hypersensitivity and contact urticaria will be considered.

Delayed hypersensitivity typically presents as a chronic eczematous eruption affecting the dorsum of the hands and wrists (3). Contact urticaria classically develops acutely within 5–30 min of wearing the gloves. The clinical hallmark is the weal, which resolve within 24 hr. Rarely, anaphylactic reactions occur. Patients with atopic disease are at increased risk of developing contact urticaria.

Within the EU, there are certain regulatory directives that employers must comply with when providing gloves in the workplace. The Use of Personal Protective Equipment (PPE) Directive 89/656/EEC requires that the properties necessary in gloves to protect employees must be defined and that all gloves must conform to the PPE Directive and EN standards. The EN Standard 420: 2003 defines general requirements and relevant test procedures for gloves (4). With regard to sensitizing potential, it states that the gloves should not cause 'harm to the user', that chromium (VI) content should be undetectable (<10 p.p.m.) and that natural rubber should be tested for extractable proteins using methods defined in the EN Standard 455–3. Glove manufacturers within the EU are now also required under the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) initiative to comply with further regulations regarding disclosure of information about their products. This process is currently being designed to provide additional information on the use of chemicals and to promote safe use (5).

Methods

For this review, the National Library of Medicine (PubMed, <http://www.ncbi.nlm.nih.gov/sites/entrez>)

db=Pubmed, last accessed 25 March 2009) was searched using the terms 'glove and contact allergy', 'glove and contact dermatitis', 'glove and irritant dermatitis', 'glove and contact urticaria', and 'leather gloves'. The search term 'glove and contact allergy' yielded 195 articles of which 15 were included. Excluded publications comprised those relating to the use of gloves as hand protection, articles about type 1 hypersensitivity reactions to natural rubber latex (NRL), review articles not reporting any original findings and duplicated references. The search term 'glove and irritant dermatitis' returned 33 publications of which 3 were relevant. Excluded articles again reported on contact urticaria and NRL, plus the protective role of gloves. In addition, the journals *Contact Dermatitis* and *Dermatitis* (formerly *the American Journal of Contact Dermatitis*) were searched using the aforementioned terms. References within included articles were followed up where relevant.

The level of evidence for the reported allergens has been assessed. For delayed hypersensitivity, evidence is graded as A if there was a positive patch test to the specified allergen, if the authors reported chemical analysis of the glove material or confirmation from the manufacturers that the specified allergen was an ingredient in the glove and if the patient's symptoms improved with avoidance of the identified allergen. Grade B indicates a positive patch test to the specified allergen and confirmation that this is an ingredient in the glove from analysis or indication by the manufacturer. Grade C refers to a positive patch test to the specified allergen alone. For contact urticaria, evidence is graded as A if there was a positive prick test or scratch test to the specified allergen, if the authors reported chemical analysis of the glove material or confirmation from the manufacturers that the specified allergen was an ingredient in the glove, and if the patient's symptoms improved with avoidance of the identified allergen. Grade B indicates a positive prick test or scratch test to the specified allergen and confirmation that this is an ingredient in the glove from analysis or indication by the manufacturer. Grade C refers to a positive prick test or scratch test to the specified allergen alone (see Table 1).

Information regarding ingredients reported to be used in glove manufacture was supplied by the UK distributor Arco® (Hull, UK) following liaison with their suppliers, predominantly based in China. This is information that would be available to customers on request.

Rubber Gloves

Contact allergic dermatitis related to the use of rubber gloves is usually caused by various chemicals

Table 1. Level of evidence for allergens reported to cause glove allergy

Grade of evidence	Delayed hypersensitivity	Contact urticaria
Grade A	Positive patch test to specified allergen	Positive prick or scratch test to specified allergen
	Allergen confirmed ingredient in glove (chemical analysis or manufacturer confirmation)	Allergen confirmed ingredient in glove/glove powder (chemical analysis or manufacturer confirmation)
	Symptoms improve with avoidance	Symptoms improve with avoidance
Grade B	Positive patch test to specified allergen	Positive prick or scratch test to specified allergen
	Allergen confirmed ingredient in glove (chemical analysis or manufacturer confirmation)	Allergen confirmed ingredient in glove/glove powder (chemical analysis or manufacturer confirmation)
Grade C	Positive patch test to specified allergen	Positive prick or scratch test to specified allergen

added to or used during their production, rather than to the rubber *per se*. This is true for both NRL and synthetic rubber gloves such as neoprene and nitrile.

Delayed Hypersensitivity

Vulcanizers and accelerators

The process by which the rubber hydrocarbon chains are cross-linked to make the material elastic is known as vulcanization. Accelerators are used to speed up this reaction and it is well recognized that this group includes the relevant allergens for most patients with rubber glove allergy. In a large retrospective review, Geier et al. (1) reported that the thiurams [tetraethylthiuram disulfide (TETD), tetramethylthiuram monosulfide (TMTM), tetramethylthiuram disulfide (TMTD), and dipentamethylenethiuram disulfide (DPTD)] were still the commonest allergens, with TETD being most frequently implicated (level of evidence C). This is despite the reported replacement of thiurams by other chemical compounds during glove manufacture. Other significant allergens identified were the dithiocarbamates zinc diethyldithiocarbamate (ZDEC) and zinc dibutyldithiocarbamate (ZDBC) (level of evidence C). The frequencies reported by Geier are mirrored in other reviews (6,7) (level of evidence C and C, respectively). 1,3-Diphenylguanidine (1,3-DPG) is a less common sensitizer in the carba mix

group (ZDEC, ZDBC, zinc dimethyldithiocarbamate (ZDMC) and 1,3-DPG) although Geier et al. comment that it has a low reaction index and therefore it may be difficult to distinguish irritant and allergic reactions (level of evidence C) (1). A further series of four patients has been presented with glove allergy related to the use of gloves containing 1,3-DPG (level of evidence B) (8). There is one report of the dithiocarbamate ZDMC causing glove allergy (level of evidence A) (9). Cross-reactivity may occur between the thiurams and the dithiocarbamates and there has been debate as to whether this actually represents concomitant sensitization. Cross-reactivity is potentially explained by the chemical structure similarities between thiurams and carbamates and is supported by some *in vitro* studies and animal studies (10,11). However, other authors propose that the range of frequencies of positive reactions seen to occur in the two groups may indicate variation in exposure rates and suggest concomitant sensitization to be more likely (3). Geier et al. observe that for both groups the compounds with longer chains were less potent sensitizers (DPTD for the thiurams and ZDBC for the dithiocarbamates) (1). Geier et al. also report reactions to mercaptobenzothiazole (MBT) and its derivatives [morpholinylmercaptobenzothiazole (MOR), *N*-Cyclohexyl-2-benzothiazylsulfenamide (CBS), and dibenzothiazyl disulfide (MBTS)], MOR being the commonest in the subgroup (level of evidence C). In addition, Estlander et al. (7) describe reactions to the accelerator hexamethylenetetramine (HEXA) (level of evidence C), which has also been reported by other authors (12) (level of evidence C).

The thioureas are also used as accelerators, especially in the manufacture of neoprene. Geier et al. reported positive reactions to dibutyl thiourea and diphenyl thiourea in only 0.1% and 0.3%, respectively of all patients with suspected glove allergy (level of evidence C) (1). However, a recent report found gloves to be the commonest occupational source of allergic contact dermatitis to diethyl thiourea and dibutyl thiourea (13).

Retarders such as cyclohexylthiophthalimide are also used in the rubber industry to slow the process of vulcanization. It is used in the manufacture of gloves but washed off during production with the aim of being undetectable in the finished item (P Lyon, personal communication). There is one report describing positive patch tests to this agent in patients with glove allergy and allergy to other rubber items (level of evidence C). However, in all three patients who had a positive reaction to their own gloves, there was concomitant reaction to thiuram (14).

Antioxidants

These groups of chemicals are added to rubber to inhibit rubber degeneration by oxygen and ozone. They represent another important cause of delayed hypersensitivity in glove users. Estlander et al. retrospectively reviewed their patients with glove allergy (7). Positive reactions were found for the antioxidant amines *N*-isopropyl-*N*'-phenyl-paraphenylenediamine (IPPD) and *N*-cyclohexyl-*N*'-phenyl-paraphenylenediamine (CPPD) but these appear to be decreasing in frequency (level of evidence C). Further rare causes include *N,N*-diphenyl-*p*-phenylene-diamine (DPPD) (level of evidence C) (15), methylcyclohexyldimethylphenol in unstipulated rubber gloves (level of evidence A) (3), 4,4'-dihydroxydiphenyl (level of evidence A) (16), 4,4'-thiobis(6-*tert*-butyl-*meta*-cresol) (Lowinox® 44S36) and butylated hydroxyanisole (BHA) (level of evidence A) (17), and phenyl- β -naphthylamine (level of evidence C) (18).

Antimicrobials

Cetyl pyridinium chloride is a quaternary ammonium compound which is used commonly as an antimicrobial in a number of products, including gloves. There have been several reports implicating this chemical in glove allergy (19,20) (level of evidence A and B, respectively).

Latex

Despite the frequency with which NRL causes contact urticaria, there is only one report of NRL being the implicated allergen in gloves causing delayed hypersensitivity. The authors described a series of patients with positive patch testing to NRL and in two patients this appeared to be the only relevant allergen (level of evidence B) (18).

Contact Urticaria

NRL is a well-recognized allergen and in view of the extensive published literature on this subject it will not be addressed in detail here. It is the commonest cause of occupational contact urticaria (21), often involving the hands of health care workers but can also cause irritant dermatitis and rarely delayed hypersensitivity. The allergens are NRL proteins and the use of powdered gloves is known to increase exposure to NRL aeroallergens (>3500 particles/m³ air) whereas low-protein powder-free gloves produce aeroallergen levels below 5 ng/m³ (4, 22).

Glove powder

There are rare reports of the glove powder being the responsible allergen in glove contact urticaria (6). In

some patients, the allergen has been identified as the corn component of cornstarch powder in the gloves (23–26) (level of evidence B, B, B, and B, respectively). Cornstarch has been used in the manufacturing process as a donning agent. It is also used in the production of so-called powder-free gloves but is washed off during a chlorination step.

Casein

Ylitalo et al. highlighted that casein may be added during the manufacture of latex gloves and that it may result in contact urticaria in patients known to be allergic to cow's milk (level of evidence B) (27).

Accelerators

These chemicals have also been infrequently reported to cause contact urticaria. This has been described for ZDEC (level of evidence A) (28), TMTD (level of evidence C) (29), zinc pentamethylene dithiocarbamate, ZDBC (level of evidence C) (30), and MOR (level of evidence B) (31).

Plastic Gloves

The manufacture of plastic gloves involves the use of various polymers including polyvinyl chloride (PVC), polyvinyl alcohol (PVA), polyethylene, and polyvinylacetate. Once again, the addition of chemicals during production often introduces potential allergens.

Delayed Hypersensitivity

Plasticizers

These compounds are added to plastics in small amounts (<5%) to harden them or in large amounts (30–50%) to soften them. There have been isolated reports of the plasticizers, adipic polyester (level of evidence A) and poly(adipic acid-co-1,2-propylene glycol) causing allergic contact dermatitis (32,33). In the latter case, this was also associated with positive patch testing to the stabilizer di-(*n*-octyl) tin-bis(2-ethylhexylmaleate) (level of evidence A), which has also been reported as the responsible allergen in isolation (level of evidence A) (34). A further group of plasticizers are the epoxy resins. It is documented that these are used in the manufacture of PVC gloves (35). To our knowledge, there are no reported cases of glove allergy secondary to epoxy resins in plastic gloves but they remain a potential allergen.

Estlander et al. reported one patient with delayed hypersensitivity to plastic gloves who had positive patch test reactions to the components tricresyl

phosphate, triphenyl phosphate, and methyldichlorobenzenesulfonate from the plastics and glue series (level of evidence C). The relevance of these results was uncertain (7).

Antioxidants

Bisphenol A is used as an antioxidant and as an inhibitor of end polymerization in the manufacture of PVC gloves. It is a rare allergen but there are several reports of contact allergy in the setting of PVC glove use (36,37) (level of evidence A and B, respectively).

Antimicrobials

There have been several reports from the same authors about patients found to be allergic to the antimicrobial agent 1,2 benzisothiazolinone (level of evidence A) (38,39). This was only present in certain powder-free PVC gloves. Formaldehyde has been found to be the underlying cause in one patient with glove allergy (level of evidence B) (40). The authors suggest that formaldehyde may be added to the gloves during manufacture either as such or in the form of a formaldehyde releaser.

Colouring agents

There has only been one report of contact dermatitis secondary to the colourant Irgalite Orange® F2G (Pigment Orange 34, C.I. 21115) (level of evidence B) (7).

Contact Urticaria

Plasticizers

There have been several reports of contact urticaria secondary to the plasticizer di(2-ethylhexyl)phthalate in PVC gloves (level of evidence B) (41) and in polyethylene gloves but in the latter case the patient also had positive prick testing to octadecanoic acid methyl ester, 2,6-di-tert-butylphenol, *cis*-13-docosenoic acid amide (Erucamide) and octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate (Irganox® 1076) and the authors could not determine which was the most likely allergen (level of evidence B) (42).

Leather Gloves

Chromate allergy is well recognized in occupational leather exposure, and there are specific reports of leather glove allergy (level of evidence B) (43). Chromium (III) sulfate is used in the tanning process and may be oxidized during this procedure to form chromium (VI), a potent, highly bioavailable

contact allergen. Following tanning, chromium (III) is bound to collagen resulting in a lower bioavailability and is therefore less likely to elicit contact dermatitis but studies suggest that it may also play a role. Chromate is released when leather gloves become moist and this can result in delayed hypersensitivity.

Significant levels of chromium (VI) have been detected in a number of leather products, including protective gloves (44). Nonetheless, EU standards stipulate the requirement for chromium (VI) to be undetectable.

Textile Gloves

There is an isolated report of textile dyes resulting in delayed hypersensitivity through the use of protective gloves, in contrast to the relatively common occurrence of textile dye contact dermatitis resulting from other clothing. In this case, there were positive reactions to Disperse Orange 3, Acid Red 118, Direct Orange 34, Dispersed Red 17, Disperse Blue 35, Disperse Orange, and 4-aminoazobenzene (level of evidence C) (45).

Glove Ingredients

Information supplied by Arco[®], together with a survey of a number of unspecified Chinese glove manufacturers has been used to compile Table 2 with all confirmed ingredients used in the manufacture of rubber and plastic gloves. In addition, allergens reported to cause delayed hypersensitivity and contact urticaria which were confirmed in the publications to be glove ingredients have also been included. This is, therefore, unlikely to be complete.

Glove Series

In view of the recognized glove allergens and the reported glove ingredients, a proposed series for investigating patients with suspected glove allergy is presented in Tables 3 and 4.

In Table 3, the suggested series for patients presenting with delayed hypersensitivity related to glove use incorporates the most frequently reported allergens in quoted review articles, in addition to those rarer allergens presented in this article with level of evidence Grade A.

In Table 4, the suggested series for patients presenting with contact urticaria as a consequence of glove use includes NRL together with allergens presented here with level of evidence A or B.

Discussion

Investigation of potential glove-induced delayed hypersensitivity typically involves patch testing and

Table 3 includes allergens which may be considered. In addition, it is important to patch test with material from the glove. Typically, this would be with a piece of glove material cut from the glove and applied under occlusion. False-positive reactions may occur secondary to pressure from the glove material underneath the Finn Chambers[®] but these must be interpreted in light of the patient's history. Although it is possible to produce solvent-based extracts for the purpose of patch testing, this is likely only to be available in a limited number of centres. If delayed hypersensitivity to latex is suspected, accelerator-free latex fluid is requested from the manufacturer and is also tested. Finally if results are equivocal then a glove use test may be performed. The patient wears the gloves for 2 hr daily over 3 days and is then assessed (6). This, however, would not distinguish between allergic and irritant contact dermatitis.

Compound allergy is a theoretical explanation for the presence of a positive patch test to a finished product despite negative reactions to the individual ingredients present. It was proposed by Calnan (46) and may occur due to manufacturing processes. Compound allergy in gloves should be detected using the glove use test.

It is also useful to consider a use test for investigating glove-related contact urticaria if prick testing/specific IgE for suspected allergens is negative but the history is suggestive. The patient wears the glove for 20 min in an observed setting to ensure that any resulting urticaria is not dermographism secondary to scratching (30). A control glove is worn on the other hand.

Choosing gloves

If patients are found to have a positive patch test or prick test to a glove allergen, they must obviously avoid the identified allergen while continuing to use a glove which offers appropriate protection. Glove manufacturers publish guidance on the permeation (i.e. the passage of chemicals through the glove material) and degradation (i.e. the reduction in the physical properties of the glove as a result of exposure to given chemicals) qualities of glove. This information aids determination of the most suitable glove for use in specific conditions, for example at www.ansellpro.com.

Conclusion

Although the majority of patients with glove allergy are allergic to chemicals classed as rubber accelerators, there are an increasing number of other, rarer components being reported which may cause a reaction. Increasing awareness of these will aid

Table 2. Glove ingredients confirmed to be in gloves (published articles, together with information supplied by industry)

Chemical component	Reported allergen in gloves	Latex	Nitrile	Neoprene	PVC	CAS number
Zinc oxide	No	Yes	Yes	No	No	1314-13-2
Titanium dioxide	No	Yes	Yes	No	No	13463-67-7
Calcium nitrate	No	Yes	Yes	No	No	13477-34-4
Fillers						
Calcium carbonate	No	Yes	No	No	No	471-34-1
Zinc sulfide	No	Yes	No	No	No	1314-98-3
Barium sulfate	No	Yes	No	No	No	7727-43-7
Plasticizers						
Naphthenic oil	No	Yes	No	No	No	
Paraffinic process oil	No	Yes	No	No	No	
Epoxy resins	Possible	No	No	No	Yes	
Adipic polyester	Yes (32)	No	No	No	Yes	
Poly(adipic acid-co-1,2-propylene glycol)	Yes (33)	No	No	No	Yes	25101-03-5
Stabilizers						
Potassium oleate	No	Yes	No	No	No	143-18-0
Triethanolamine oleate	No	Yes	No	No	No	2717-15-9
Casein	Yes (27)	Yes	Yes	No	No	9000-71-9
Di(2-ethylhexyl) phthalate	Yes (41)	No	Yes	No	Yes	117-81-7
Dibutyl phthalate	No	No	No	No	Yes	84-74-2
Di-(<i>n</i> -octyl)	Yes (33)	No	No	No	Yes	10039-33-5
tin-bis(2-ethylhexylmaleate)						
Antioxidants						
Bisphenol A	Yes (36,37)	No	No	No	Yes	80-05-7
Methylcyclohexyldimethylphenol	Yes (3)	Unknown	Unknown	No	No	
4,4'-thiobis(6- <i>tert</i> -butyl- <i>meta</i> -cresol)	Yes (17)	Yes	No	No	No	96-69-5
(Lowinox® 44S36)						
Butylated hydroxyanisole (BHA)	Yes (17)	Yes	No	No	No	9009-68-1
2-Tertiary-butyl-4-methylphenol	No	No	Yes	No	No	2409-55-4
4,4'-Dihydroxydiphenyl ether	Yes (17)	No	No	Yes	No	1965-09-9
N-isopropyl-N'-phenyl-paraphenylenediamine	Yes (15)	Yes	Yes	No	No	101-72-4
N-cyclohexyl-N'-phenyl-paraphenylenediamine	Yes (7)	Yes	Yes	No	No	101-87-1
Accelerators						
Mercaptobenzothiazole	Yes (1)	Yes	Yes	Yes	No	149-30-4
N-Cyclohexyl-2-benzothiazylsulfenamide	Yes (1)	Yes	Yes	Yes	No	95-33-0
Morpholinylmercaptobenzothiazole	Yes (1)	Yes	Yes	Yes	No	102-77-2
Dibenzothiazyl disulfide	Yes (1)	Yes	Yes	Yes	No	120-78-5
Zinc diethyldithiocarbamate	Yes (1,7,15)	Yes	Yes	Yes	No	14324-55-1
Zinc dibutyldithiocarbamate	Yes (1,7,15)	Yes	Yes	Yes	No	136-23-2
Zinc dimethyldithiocarbamate	Yes (1,10)	Yes	Yes	Yes	No	137-30-4
1,3-Diphenylguanidine	Yes (1,8)	Yes	Yes	Yes	No	102-06-7
Tetraethylthiuram disulfide	Yes (1,7,15)	Yes	Yes	Yes	No	97-77-8
Tetramethylthiuram monosulfide	Yes (1,7,15)	Yes	Yes	Yes	No	97-74-5

Table 2. (Continued)

Chemical component	Reported allergen in gloves	Latex	Nitrile	Neoprene	PVC	CAS number
Tetramethylthiuram disulfide	Yes (1,7,15)	Yes	Yes	Yes	No	137-26-8
Dipentamethylenethiuram disulfide	Yes (1,7,15)	Yes	Yes	Yes	No	94-37-1
Diethyl thiourea	Yes (1,13)	Yes	Yes	Yes	No	109-46-6
Diphenyl thiourea	Yes (1)	Yes	Yes	Yes	No	102-08-9
Diethyl thiourea	Yes (13)	Yes	Yes	Yes	No	105-55-5
Pigment						
Sulfur Black	No	Yes	Yes	No	No	1326-82-5
Pigment Yellow (CI 21290)	No	Yes	No	No	No	77804-81-0
Pigment Blue 15:1 (CI 74160:3)	No	No	Yes	No	No	147-14-5
Pigment Green 7 (CI 74260)	No	No	Yes	No	No	1328-53-6
Carbon black	No	Yes	No	No	No	
Pigment Red 122 (CI 73915)	No	Yes	No	No	No	980-26-7
Disperse Yellow 134 (CI 47023)	No	No	No	No	Yes	12223-86.8
Surfactant						
Fatty alcohol polyglycol ethers	No	Yes	Yes	No	No	
Dowfax™ (mono- & di-alkyl diphenyl oxide disulfonate Disodium salt)	No	No	Yes	No	No	
Thickener						
Polyamide	No	Yes	Yes	No	No	63428-83-1
Sodium carboxymethyl cellulose	No	Yes	Yes	No	No	9004-32-4
Ammonia solution	No	Yes	Yes	No	No	7664-41-7
Defoamer						
Blend metallic soaps/mild non-ionic surfactants	No	Yes	No	No	No	
Mineral oil	No	No	Yes	No	No	
Tackifier						
Terpene phenolic resin	No	No	Yes	No	No	
Cross-linking agent	No	No	Yes	No	No	
Methylated melamine resin	No	No	Yes	No	No	
Anticaking agent	No	No	Yes	No	No	
Silica with medium oil absorption	No	No	Yes	No	No	
Emulsion	No	No	Yes	No	No	
Polyvinyl alcohol (PVA)	No	No	Yes	No	No	
Promoter						
Methanol	No	Yes	Yes	No	No	79757-77-0
Disperser						
Xylene	No	Yes	No	No	No	95-47-6
Antimicrobials						
Formaldehyde	Yes (40)	No	No	No	Yes	50-00-0
1,2 Benzisothiazolinone	Yes (28,39)	No	No	No	Yes	2634-33-5
Cetyl pyridinium chloride	Yes (19,20)	Yes	No	No	No	123-03-5
Corn starch powder	Yes (23–26)	Yes	Yes	No	No	

CAS, Chemical Abstracts Service registration number; PVC, polyvinyl chloride

Table 3. Suggested chemicals that might form a basis for patch testing patients with suspected delayed hypersensitivity to gloves

Baseline series		
Allergen	CAS	Preparation
Mercaptobenzothiazole	149-30-4	2% pet
Potassium dichromate	7778-50-9	0.5% pet
Carba mix ^a		3% pet
Thiuram mix		1% pet
Formaldehyde	50-00-0	1% aq
Mercapto mix		2% pet
N-isopropyl-N'-phenyl-paraphenylenediamine	101-72-4	0.1% pet
Epoxy resins		1% pet

^aNot in European Baseline Series

Additional series

Allergen	CAS	Preparation
Rubber series		
Mercapto mix		
N-Cyclohexyl-2-benzothiazylsulfenamide	95-33-0	1% pet
Morpholinylmercaptobenzothiazole	102-77-2	0.5% pet
Dibenzothiazyl disulfide	120-78-5	1% pet
Thiuram mix		
Tetraethylthiuram disulfide	97-77-8	0.25% pet
Tetramethylthiuram monosulfide	97-74-5	0.25% pet
Tetramethylthiuram disulfide	137-26-8	0.25% pet
Dipentamethylenethiuram disulfide	94-37-1	0.25% pet
Carba mix		
Zinc diethyldithiocarbamate	14324-55-1	1% pet
Zinc dibutyldithiocarbamate	136-23-2	1% pet
Zinc dimethyldithiocarbamate	137-30-4	1% pet
1,3-Diphenylguanidine	102-06-7	1% pet
Black rubber mix		
N-cyclohexyl-N'-phenyl-paraphenylenediamine	101-87-1	1% pet
Thioureas		
Dibutylthiourea	109-46-6	1% pet

Additional series

Allergen	CAS	Formulation
Diphenyl thiourea	102-08-9	1% pet
Diethyl thiourea	105-55-5	1% pet
Dialkyl thiourea mix		1% pet
Butylated hydroxyanisole (BHA)	9009-68-1	2% pet
1,2-Benzisothiazolinone	2634-33-5	0.05% pet
4,4'-Dihydroxydiphenyl ether	1965-09-9	0.1% pet
Plastic and glue series		
Bisphenol A	80-05-7	1% pet

Non-commercially available substances

4,4'-thiobis(6-tert-butyl-meta-cresol) (Lowinox® 44S36)	96-69-5	1% pet
Cetyl pyridinium chloride	123-03-5	0.1% aq
Adipic polyester		5% pet
Poly(adipic acid-co-1,2-propylene glycol)	25101-03-5	5% pet
Di-(n-octyl) tin-bis(2-ethylhexylmaleate)	10039-33-5	1% pet
Methylcyclohexyldimethylphenol		1% pet

Aq, aqueous; pet, petrolatum.

investigation of these patients in the future. It is likely that new allergens will continue to be identified given the extensive number of ingredients that are used in glove manufacture.

Table 4. Suggested chemicals that might be considered for prick testing patients with suspected contact urticaria to gloves

Latex
Casein
Corn starch powder
Zinc diethyldithiocarbamate
Morpholinylmercaptobenzothiazole
Di(2-ethylhexyl)phthalate

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