

Rubber Accelerators in Medical Examination and Surgical Gloves

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Background: Rubber accelerators play a significant role in glove-related occupational contact dermatitis, especially among health care workers. Currently, there is limited information readily available outlining the accelerators used in specific medical examination and surgical gloves.

Objective: The aim of this study was to ascertain the accelerators used in medical examination and surgical gloves for major glove manufacturers within the United States.

Methods: An initial Internet-based search was performed to establish relevant manufacturers and product lines, with subsequent inquiry with each corresponding company regarding accelerators used in each medical and surgical glove line.

Results: Eleven glove manufacturers were identified and contacted. Responses were obtained from all manufacturers, but because of legal limitations, changes in product lines, or inability to supply necessary data, only 8 companies were able to be included in the final analysis, totaling data for 190 gloves. Carbamates were the most common accelerator, used in 90.5% (172/190) of gloves, whereas thiurams were used in only 11 gloves (5.8%). Eight companies surveyed are now advertising and offering touted accelerator-free gloves.

Conclusions: Accelerators are used in most examination and surgical gloves; however, manufacturers are now expanding their product offerings to include accelerator-free options.

Gloves are a fundamental component of personal protective equipment used in health care. Contact reactions to gloves—both latex and nonlatex rubber based—pose a significant occupational hazard to health care workers.^{1–3} Widespread sensitivity to latex gloves led companies to transition from latex to nonlatex natural and synthetic rubber-derived gloves, such as nitrile, polyisoprene, and polychloroprene. Although the move to powder-free gloves and latex alternatives did diminish the prevalence of latex-related dermatitis and urticaria,^{4–6} reports of contact dermatitis related to nitrile gloves rose.⁷ The culprit allergens in these gloves are rubber accelerators, which are used in the manufacturing process to speed up the rubber vulcanization process.

Five main families of accelerants are used in rubber-derived gloves: thiurams (tetramethylthiuram monosulfide, tetramethylthiuram disulfide, tetraethylthiuram disulfide, dipentamethylenethiuram disulfide, and dipentamethylenethiuram tetrasulfide), dithiocarbamates

(CM) (zinc diethyldithiocarbamate [ZDEC], zinc dibutyldithiocarbamate [ZDBC], zinc dimethyldithiocarbamate, and zinc dibenzoyldithiocarbamate), benzothiazoles (2-mercaptobenzothiazole [MB], N-cyclohexyl-2-benzothiazyl sulfonamide, dibenzothiazyl disulfide, and morpholinyl MB), guanides (1,3-diphenylguanidine [DPG]), and thioureas (dibutylthiourea, diphenylthiourea, diethylthiourea, and thiourea). Accelerators speed up the rate of vulcanization to varying degrees: the thiourea derivatives are slow, 1,3-DPG and MBs are moderately fast, and thiurams and CM are fast accelerators.⁸

Unfortunately, these accelerators remain in the final glove product and may be released over time, causing sensitization and allergic contact dermatitis (ACD).^{9,10} In certain medical professions, such as nursing, the prevalence of contact dermatitis to these rubber accelerators—among patch-tested patients—is as high as 6.7%.¹¹ Despite the well-described allergenicity of these accelerators, there are no reporting requirements obligating manufacturers to declare which accelerators are used in their glove production. Without this information, safe alternatives for accelerator patch-test-positive patients are difficult to ascertain.

The purpose of this study was to confirm which rubber accelerators are used in the manufacturing of commonly used surgical and medical examination glove brands and present this information in an easily accessible repository for physicians.

MATERIALS AND METHODS

Selection of Gloves

On July 2016, we set out to compile a list of relevant glove manufacturers with distribution in the United States. We began by

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TABLE 1. Accelerators Used in Nitrile Patient Examination Gloves

Nitrile Examination Gloves						
Company	Product	TH	CM	MB	MM	DT
Adenna 201 S Milliken Ave, Ontario, CA 91761 Information: 1-888-3ADENNA (1-888-323-3662) www.adenna.com Ansell Healthcare LLC 111 Wood Ave, Suite 210, Iselin, MN 08830 Ordering: 1-855-868-5540 www.ansell.com	EMPOWER Nitrile Powder Free	No	Yes	No	No	No
	EMPOWER-LC Nitrile Powder Free	No	Yes	No	No	No
	Miracle Nitrile Powder Free	No	Yes	No	No	No
	NPF Nitrile Powder Free	Unknown	Unknown	Unknown	Unknown	Unknown
	Precision Nitrile Powder Free	Unknown	Unknown	Unknown	Unknown	Unknown
	WNF Nitrile Powder Free	Unknown	Unknown	Unknown	Unknown	Unknown
	Microflex Black Dragon	No	Yes	Unknown	No	No
	Zero BD-1000-NPF	No	Yes	No	No	No
	Microflex Blaze N48	No	Yes	No	No	No
	Microflex Cobalt N19	No	Yes	Unknown	No	No
Hourglass International, Inc PO Box 96, Benicia, CA 94510 Ordering: 1-800-277-0994 www.hourglass-intl.com	Microflex Performance	No	Yes	Unknown	No	No
	Series Nitrile PN-290	No	Yes	Unknown	No	No
	Microflex Soft White Nitrile TQ-601	No	Yes	Unknown	No	No
	Microflex Ultraform UF-524	No	Yes	Unknown	No	No
	Microflex XCEED XC-310	No	Yes	Unknown	No	No
	MICRO-TOUCH Micro-Thin Nitrile	No	Yes	No	No	No
	Micro-Touch Nitra-Tex Sterile	No	Yes	No	No	No
	Micro-Touch Nitrile	No	Yes	No	No	No
	Micro-Touch Nitrile E.P.	No	Yes	No	No	No
	HandPRO AirSoft Nitrile Exam	No	Yes	No	No	No
Medline Industries, Inc One Medline Place, Mundelein, IL 60060 Ordering: 1-800-MEDLINE (1-800-633-5463) www.medline.com	HandPRO Cirrus800 Nitrile Exam	No	Yes	No	No	No
	HandPRO RoyalTouch300 Nitrile Exam	No	Yes	No	No	No
	Accutouch Chemo Nitrile Exam Gloves	No	Yes	No	No	No
	Aloetouch Ice Powder-Free Nitrile Exam Gloves	No	Yes	Yes	No	No
	Aloetouch 12" Powder-Free Nitrile Exam Gloves	No	Yes	No	No	No
	Aloetouch 9" Powder-Free Nitrile Single Exam Gloves	No	Yes	No	No	No
	Aloetouch Extended Cuff Chemo Nitrile Exam Gloves	No	Yes	No	No	No
	Critical Response Nitrile Exam Gloves	No	Yes	No	No	No
	CS Pro Extended Cuff Nitrile Exam Gloves	No	Yes	No	No	No
	CURAD Nitrile Exam Gloves	No	Yes	No	No	No
CURAD White Nitrile Exam Gloves		No	Yes	Yes	No	No

(continued on next page)

TABLE 1. (Continued)

Nitrile Examination Gloves								
Company	Product	TH	CM	MB	MM	DT	DPG	
Sempermed USA, Inc 13900 N 49th St, North Clearwater, FL 33762 Ordering: 1-800-366-9545 http://www.sempermedusa.com/	FitGuard Nitrile Exam Gloves	No	Yes	No	No	No	No	
	FitGuard Select Nitrile Exam Gloves	No	Yes	No	No	No	No	
	FitGuard Touch Nitrile Exam Gloves	No	Yes	No	No	No	No	
	FitGuard Ultra Nitrile Exam Gloves	No	Yes	No	No	No	No	
	Generation Pink Pearl Nitrile Exam Gloves	No	Yes	No	No	No	No	
	Generation Pink Nitrile Exam Gloves	No	Yes	No	No	No	No	
	Medline Professional Lightly Textured	No	Yes	Yes	No	No	No	
	Aloe Exam Gloves							
	Medline Professional Nitrile Exam	No	Yes	No	No	No	No	
	Gloves with Aloe							
	Medline Sterile Powder-Free	No	Yes	No	No	No	No	
	Non-Latex Nitrile Exam Gloves							
	Restore Nitrile Exam Gloves with Oatmeal	No	Yes	No	No	No	No	
	SensiCare Ice Blue Nitrile Exam Gloves	No	Yes	No	No	No	No	
	SensiCare Silk Nitrile Exam Gloves	No	Yes	No	No	No	No	
	SensiCare 200 Nitrile Exam Gloves	No	Yes	No	No	No	No	
	SensiCare Extended Cuff Nitrile	No	Yes	No	No	No	No	
	Exam Gloves							
	SensiCare Nitrile Exam Gloves	No	Yes	No	No	No	No	
	Solstice Nitrile Powder-Free	No	Yes	No	No	No	No	
	Exam Gloves							
SmartPractice 3400 E McDowell, Phoenix, AZ 85008 Ordering: 1-800-522-0800 www.smartpractice.com	Venom Black Nitrile Exam Gloves	No	Yes	No	No	No	No	
	Best Touch Nitrile	No	Yes	Yes	No	No	No	
	SemperShield Nitrile	No	Yes	Yes	No	No	No	
	StarMed PLUS Nitrile	No	Yes	Yes	No	No	No	
	StarMed ROSE Nitrile	No	Yes	Yes	No	No	No	
	StarMed Sterile Nitrile	No	Yes	Yes	No	No	No	
	StarMed Ultra Nitrile	No	Yes	Yes	No	No	No	
	Tender Touch Nitrile	No	Yes	Yes	No	No	No	
	Dexterity 300 Nitrile PF Blue	No	Yes	No	No	No	No	
	Dexterity Nitrile PF Blue	No	Yes	No	No	No	No	
CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.	Kulorful Squiggly Nitrile PF	No	Yes	No	No	No	No	
	Vanilla Scented Blue							
	Pink Ribbon PF Nitrile	No	Yes	No	No	No	No	
	QualiTouch Nitrile PF White	No	Yes	No	No	No	No	
	QualiTouch Fitted Nitrile PF Blue	No	Yes	No	No	No	No	
	Reflection White PF Nitrile	No	Yes	No	No	No	No	

contacting companies outlined in the 2007 publication by Scheman et al,¹² cross-referencing each to ensure that they were still in production and had not been acquired by another entity. To supplement this inventory, an Internet-based search was performed to identify other suppliers that were not in existence in 2007. Gloves were selected based on name recognition, as well as general Web presence, because sales data for specific glove lines were not available to guide glove selection.

The accelerators used in their medical examination and surgical gloves were determined using a 2-step approach: first, each company's Web site was reviewed for relevant material safety data sheets (MSDSs). If no documentation was readily available, customer service representatives were contacted for this information.

The MSDS or information provided by the company was reviewed for the presence of 6 accelerators: thiuram mix (TH), CM, MB, mercapto mix (MM), DPG, and dialkyl thioureas (DT). (Note, MM—as a screening agent—includes MB and *N*-cyclohexylbenzothiazyl-sulfenamide and dibenzothiazyl disulfide; however, MB was reported separately.) In addition to these accelerators, gloves were evaluated for black rubber mix and natural rubber latex.

Data collection was performed using Excel (Excel, 2010; Microsoft Corporation, Redmond, WA).

RESULTS

Glove Manufacturers

Eleven glove manufacturers provided sufficient information to be used in this study: Adenna (Ontario, CA); Ansell Healthcare LLC (Iselin, NJ); CardinalHealth (Dublin, OH); Hourglass International, Inc (Benicia, CA); Medline Industries, Inc (Mundelein, IL); Mölnlycke Health Care US LLC (Norcross, GA); Sempermed USA, Inc (Clearwater, FL); SmartPractice (Phoenix, AZ); Halyard Health (Alpharetta, GA); SHOWA, a division of Globus Ltd (Manchester, United Kingdom); and Dynarex Corporation (Orangeburg, NY). Of these companies, the first 8 provided MSDS or written

documentation regarding the accelerators used in examination and surgical glove lines. Halyard Health provided the relevant information with the authors, unfortunately with the stipulation that these data could not be shared and distributed to others. Similarly, CardinalHealth disclosed the accelerators used in their surgical glove line but not the medical examination gloves because representatives cited that this was “proprietary information.” Dynarex disclosed information regarding their accelerator-free glove offering only. Thus, in total, 198 gloves were evaluated, but only 190 could be published because of the aforementioned stipulations.

Medical Examination and Surgical Gloves

Tables 1 to 6 outline the accelerators used in specific company glove lines. Overall, carbamates were by far the largest accelerator constituent reported, which were used in 90.5% (172/190) of the glove lines (Table 7). Where information regarding specific carbamates was available (*n* = 98), 17.3% of the gloves used ZDEC, 29.6% used ZDBC, and 53.1% used a combination of the two. Mercaptobenzothiazole was used in the production of 19.5% (37/190) of gloves, and DPG was used in 9.5% (18/190) of gloves. For the other accelerants, DT was in 8.9% (17/190) of gloves; thiurams were present in only 2 glove lines, totaling 11 gloves (5.8%): Medline's polyisoprene surgical gloves (Sensicare) and one of Ansell Healthcare's latex patient examination gloves (MICRO-TOUCH E.P.). Black rubber, containing antioxidants, and MM were not identified in any of the gloves per the manufacturers.

Twelve gloves from 8 companies were reported as accelerator free, a summary of which can be found in Tables 8 and 9.

DISCUSSION

Sensitization to rubber accelerants is common among health care workers and is significantly higher than that seen within the general population.^{3,13} Review of data from the North American Contact Dermatitis Group screening series over a 6-year period revealed TH allergy in 8.87% of health care workers compared with

TABLE 2. Accelerators Used in Polychloroprene Patient Examination Gloves

Polychloroprene Examination Gloves							
Company	Product	TH	CM	MB	MM	DT	DPG
Ansell Healthcare LLC	MICRO-TOUCH Affinity	No	Yes	No	No	No	No
SmartPractice	LeSoothe Polychloroprene White	No	Yes	No	No	No	No
	LeSoothe Sapphire Polychloroprene Violet Blue	No	Yes	No	No	No	No
	Pink Ribbon Gloves of Hope Polychloroprene Pink	No	Yes	No	No	No	No
	Reflection Polychloroprene Green	No	Yes	No	No	No	No

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

TABLE 3. Accelerators Used in Natural Rubber Latex Patient Examination Gloves

Latex Examination Gloves							
Company	Product	TH	CM	MB	MM	DT	DPG
Adenna	Bronze Latex Powder Free	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Gold Latex Powder Free	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Platinum Latex Powder Free	No	Yes	No	No	No	No
Ansell Healthcare LLC	Silver Latex Powder Free	No	Yes	No	No	No	No
	Microflex ColorTouch Pink CTP-233	No	Yes	Unknown	No	No	No
	Microflex ComfortGrip CFG-900	No	Yes	Unknown	No	No	No
	Microflex Diamond Grip Plus DGP-350	No	Yes	Unknown	No	No	No
	Microflex E-Grip L97	No	Yes	Unknown	No	No	No
	MICRO-TOUCH E.P.	Yes	Yes	Yes	No	No	No
	MICRO-TOUCH NextStep	No	Yes	No	No	No	No
	MICRO-TOUCH Plus	No	Yes	Yes	No	No	No
	MICRO-TOUCH Plus Sterile	No	Yes	No	No	No	No
	Aloetouch Powder-Free Latex Exam Gloves	No	Yes	No	No	No	No
Medline Industries, Inc	CURAD Powder-Free Textured Latex Exam Gloves	No	Yes	No	No	No	No
	Eudermic MP 12" High Risk Exam Gloves	No	Yes	No	No	No	No
	MediGuard Non-Sterile Powdered Latex Exam Gloves	No	Yes	No	No	No	No
	Medline Professional Latex Exam Gloves	No	Yes	No	No	No	No
	Medline Sterile Powder-Free Latex Exam Gloves	No	Yes	No	No	No	No
	Spruce Non-Sterile Powder-Free Latex Exam Gloves	No	Yes	No	No	No	No
	Best Touch Latex	No	Yes	Yes	No	No	No
	SemperCare Latex	No	Yes	Yes	No	No	No
	StarMed Latex	No	Yes	Yes	No	No	No
	Dexterity PF Latex	No	Yes	No	No	No	No
SmartPractice	Kulorful Sqwiggly Latex PF Exam Gloves blue or violet	No	Yes	No	No	No	No
	Le Soothe Jade PF Latex Exam	No	Yes	No	No	No	No
	Le Soothe Left/Right Fitted PF Latex Exam	No	Yes	No	No	No	No
	Le Soothe PF Latex Exam	No	Yes	No	No	No	No
	Pink Ribbon Gloves of Hope PF Latex	No	Yes	No	No	No	No
	QualiTouch Extra Latex PF Latex	No	Yes	No	No	No	No
	QualiTouch PF Latex Textured Grip	No	Yes	No	No	No	No
	QualiTouch Latex Left/Right Fitted PWD Exam	No	Yes	No	No	No	No
	QualiTouch Latex PWD	No	Yes	No	No	No	No
	QualiTouch PF Latex Left/Right Fitted Exam	No	Yes	No	No	No	No
	Reflection PF Latex	No	Yes	No	No	No	No
	SmartTouch Latex PWD	No	Yes	No	No	No	No
	SmartTouch PF Latex	No	Yes	No	No	No	No

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

TABLE 4. Accelerators Used in Polyisoprene Surgical Gloves

Polyisoprene Surgical Gloves							
Company	Product	TH	CM	MB	MM	DT	DPG
Ansell Healthcare LLC	GAMMEX Non-Latex PI	No	Yes	Yes	No	Yes	No
	GAMMEX Non-Latex PI Green	No	Yes	Yes	No	Yes	No
	GAMMEX Non-Latex PI Micro	No	Yes	Yes	No	Yes	No
	GAMMEX Non-Latex PI Ortho	No	Yes	Yes	No	Yes	No
	GAMMEX Non-Latex PI Textured	No	Yes	Yes	No	Yes	No
	GAMMEX Non-Latex PI Underglove	No	Yes	Yes	No	Yes	No
	Protexis PI	No	Yes	Yes	No	No	Yes
	Protexis PI Blue with Neu-Thera	No	Yes	Yes	No	No	Yes
	Protexis PI Classic	No	Yes	Yes	No	No	Yes
	Protexis PI Micro	No	Yes	Yes	No	No	Yes
CardinalHealth 7000 Cardinal Place, Dublin, OH 43017 Ordering: 1-800-964-5227 www.cardinalhealth.com	Protexis PI Ortho	No	Yes	Yes	No	No	Yes
	Protexis PI with Neu-Thera	No	Yes	Yes	No	No	Yes
	SensiCare PI Classic Surgical Gloves	Yes	Yes	Yes	No	No	No
	SensiCare Green with	Yes	Yes	Yes	No	No	No
	Aloe Powder-Free Surgical Gloves						
	SensiCare LT with Aloe Custom Fit	Yes	Yes	Yes	No	No	No
	Surgical Gloves						
	SensiCare LT with Aloe Surgical Gloves	Yes	Yes	Yes	No	No	No
	SensiCare Micro Powder-Free Surgical Gloves	Yes	Yes	Yes	No	No	No
	SensiCare Ortho Powder-Free	Yes	Yes	Yes	No	No	No
Medline Industries, Inc	Surgical Gloves						
	SensiCare PI Powder-Free	Yes	Yes	Yes	No	No	No
	Surgical Gloves						
	SensiCare Shield Radiation	Yes	Yes	Yes	No	No	No
	Protective Glove						
	SensiCare SLT Powder-Free	Yes	Yes	Yes	No	No	No
	Surgical Gloves						
	SensiCare with Aloe Powder-Free	Yes	Yes	Yes	No	No	No
	Surgical Gloves						
	Biogel PI	No	Yes	Yes	No	DP	Yes
Mölnlycke Health Care US LLC 5550 Peachtree Parkway, Suite 500, Norcross, GA 30092 Ordering: 1-800-843-8497 http://www.molnlycke.com/	Biogel PI Indicator Underglove	No	Yes	Yes	No	DP	Yes
	Biogel PI Micro	No	Yes	Yes	No	DP	Yes
	Biogel PI Micro Indicator Underglove	No	Yes	Yes	No	DP	Yes
	Biogel PI OrthoPro	No	Yes	Yes	No	DP	Yes
	Biogel PI Pro-Fit	No	Yes	Yes	No	DP	Yes
	Biogel PI UltraTouch	No	Yes	Yes	No	DP	Yes
	Biogel PI UltraTouch G	No	Yes	Yes	No	DP	Yes
	Biogel PI UltraTouch M	No	Yes	Yes	No	DP	Yes

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

TABLE 5. Accelerators Used in Polychloroprene Surgical Gloves

Polychloroprene Surgical Gloves							
Company	Product	TH	CM	MB	MM	DT	DPG
CardinalHealth	Protexis Neoprene	No	Yes	No	No	No	No
Medline Industries, Inc	Neolon 2G Powder-Free Surgical Gloves	No	Yes	No	No	No	Yes
Mölnlycke Health Care US LLC	Biogel Skinsense	No	Yes	No	No	DP	Yes
	Biogel Skinsense Indicator Underglove	No	Yes	No	No	DP	Yes
SmartPractice	Neosoothe Polychloroprene Sterile Surgical	No	Yes	No	No	No	No

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

TABLE 6. Accelerators Used in Natural Rubber Latex Surgical Gloves

Latex Surgical Gloves							
Company	Product	TH	CM	MB	MM	DT	DPG
Ansell Healthcare LLC	ENCORE Latex Acclaim	No	Yes	No	No	No	No
	ENCORE Latex Micro	No	Yes	No	No	No	No
	ENCORE Latex Moisturizing	No	Yes	No	No	No	No
	ENCORE Latex Ortho	No	Yes	No	No	No	No
	ENCORE Latex Textured	No	Yes	No	No	No	No
	ENCORE Latex Underglove	No	Yes	No	No	No	No
	ENCORE Perry Style 42 PF	No	Yes	No	No	No	No
	ENCORE Sensi-Touch PF	No	Yes	No	No	No	No
	No Powder	No	Yes	Yes	No	No	No
CardinalHealth	Protexis Latex	No	Yes	No	No	No	No
	Protexis Latex Basic	No	Yes	No	No	No	No
	Protexis Latex Blue with Neu-Thera	No	Yes	No	No	No	No
	Protexis Latex Classic	No	Yes	No	No	No	No
	Protexis Latex Hydrogel	No	Yes	No	No	No	No
	Protexis Latex Micro	No	Yes	No	No	No	No
	Protexis Latex with Neu-Thera	No	Yes	No	No	No	No
	Triflex	No	Yes	No	No	No	No
	Triflex Custom	No	Yes	No	No	No	No
	Triflex Orthopedic Latex Powdered	No	Yes	No	No	No	No
	Ultrafree Max Latex	No	Yes	No	No	No	No
Medline Industries, Inc	Eudermic Latex Powder-Free Surgical Gloves	No	Yes	No	No	No	No
	OR Classic Latex Powdered Surgical Gloves	No	Yes	No	No	No	No
	Radion-X Sterile Latex Powder-Free Radiation Protection Gloves	No	Yes	No	No	No	No
	Signature Glide Latex Powder-Free Surgical Gloves	No	Yes	No	No	No	No
	Signature Touch Powder-Free Latex Surgical Gloves	No	Yes	No	No	No	No
	Tradition Latex Powdered Surgical Gloves	No	Yes	No	No	No	No
	Triumph Classic Latex Powder-Free Surgical Gloves	No	Yes	No	No	No	No
	Triumph Green with Aloe Surgical Gloves	No	Yes	No	No	No	No
	Triumph Latex Powder-Free Surgical Gloves	No	Yes	No	No	No	No
	Triumph LT Latex Powder-Free Surgical Gloves	No	Yes	No	No	No	No
	Triumph Micro Latex Powder-Free Surgical Gloves	No	Yes	No	No	No	No
Mölnlycke Health Care US LLC	Triumph Natural with Aloe Surgical Gloves	No	Yes	No	No	No	No
	Triumph Ortho with Aloe Surgical Gloves	No	Yes	No	No	No	No
	Biogel Diagnostic	No	Yes	No	No	No	No
	Biogel Eclipse	No	Yes	No	No	No	No
	Biogel Indicator Underglove	No	Yes	No	No	No	No
	Biogel M	No	Yes	No	No	No	No
	Biogel Optifit Orthopaedic	No	Yes	No	No	No	No
	Biogel Sensor	No	Yes	No	No	No	No
	Biogel Super-Sensitive	No	Yes	No	No	No	No
	Biogel Surgeons	No	Yes	No	No	No	No

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

TABLE 7. Breakdown of Individual Accelerators Used in Each Glove Category

	Nitrile Patient Exam, n (%)	Polychloroprene Patient Exam, n (%)	Latex Patient Exam, n (%)	Polyisoprene Surgical, n (%)	Polychloroprene Surgical, n (%)	Latex Surgical, n (%)
Accelerator	n = 68	n = 5	n = 36	n = 31	n = 9	n = 41
TH	0 (0.0)	0 (0.0)	1 (2.8)	10 (32.3)	0 (0.0)	0 (0.0)
CM	57 (83.8)	5 (100.0)	34 (94.4)	31 (100.0)	4 (44.4)	41 (100.0)
MB	3 (4.4)	0 (0.0)	2 (5.6)	31 (100.0)	0 (0.0)	1 (2.4)
MM	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
DT	0 (0.0)	0 (0.0)	0 (0.0)	15 (48.4)	2 (22.2)	0 (0.0)
DPG	0 (0.0)	0 (0.0)	0 (0.0)	15 (48.4)	3 (33.3)	0 (0.0)
BR	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

CM indicates carbamates; BR, black rubber mix.

0.90% for the remaining patch-tested population.³ Despite the high prevalence of ACD to rubber accelerants, information pertaining to which accelerants are used in different medical gloves is not only not readily available but also difficult to acquire from manufacturers. Notably, it took several months and innumerable phone calls to obtain the data included in our results, which is impractical for a busy clinician.

Thiurams

Thiurams (tetramethylthiuram monosulfide, tetramethylthiuram disulfide, dipentamethylenethiuram disulfide, and tetraethylthiuram disulfide) have been reported as the most common rubber accelerator causing ACD overall and among health care workers specifically.^{11,14,15} A 2012 study by Geier et al¹⁶ showed that, among 1058 health care workers with an occupational dermatitis, 15% tested positive to at least 1 thiuram, compared with 3.3% testing positive to a dithiocarbamate, 2.3% testing positive to MB or its derivative, and 1% testing positive to one of the thioureas. Perhaps, as a result of the high incidence of sensitization and contact dermatitis to thiurams, manufacturers have shifted away from using thiurams to CM and MB.¹⁷ Our study corroborates this as carbamates far outnumbered thiurams reported as the accelerants in medical gloves: only 1

polyisoprene surgical glove product line and 1 latex patient examination glove were reported to use thiurams. The general move away from the use of thiurams was similarly supported by a study by Bergendorff et al,¹⁸ where high-performance liquid chromatography was performed on rubber-based gloves with no glove testing positive for thiurams.

Carbamates

There are 4 main carba chemicals used in glove manufacturing: ZDBC, ZEDC, zinc dimethyldithiocarbamate (Ziram), and zinc dibenzylthiocarbamate. In our study, carbamates were by far the most common accelerant used in medical and surgical glove manufacturing, present in 90.5% of gloves reported. Given this, it is not surprising that rates of sensitization to this accelerant are rising: a recent study by Warburton et al⁷ showed that, from 2009 to 2012, the prevalence of thiuram ACD declined to 1.87%, whereas the prevalence of allergy to carba mix increased to 2.29%, a significant increase from previous years.

Carba mix, a combination of ZDEC, ZDBC, and 1,3-DPG, is the screening allergen for carbamates and is present on the standard patch test screening series for the North American Contact

TABLE 8. Accelerator-Free Patient Examination Gloves

Accelerator-Free Medical Exam Gloves							
Company	Product (Material)	TH	CM	MB	MM	DT	DPG
Ansell Healthcare LLC	Microflex Sensation Nitrile Exam	No	No	No	No	No	No
	Micro-Touch NitraFree Nitrile Exam	No	No	No	No	No	No
CardinalHealth	Low Dermatitis Potential Nitrile Exam	No	No	No	No	No	No
Dynarex Corporation 10 Glenshaw St, Orangeburg, NY 10962 Information: 1-888-DYNAREX (1-888-396-2739) http://www.dynarex.com/	Tillotson True Advantage Nitrile Exam Gloves	No	No	No	No	No	No
	HandPRO FreeStyle1 100 Nitrile Exam	No	No	No	No	No	No
	SemperSure Nitrile Exam	No	No	No	No	No	No
	Reflection Sapphire Sensitive Nitrile PF Violet Blue	No	No	No	No	No	No
Hourglass International, Inc	Ultimate N-DEX Free Nitrile Powder Free Exam Glove	No	No	No	No	No	No
Sempermed USA, Inc							
SmartPractice							

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

TABLE 9. Accelerator-Free Surgical Gloves

Accelerator-Free Surgical Gloves							
Company	Product (Material)	TH	CM	MB	MM	DT	DPG
Ansell Healthcare LLC	GAMMEX Non-Latex Neoprene Surgical Glove	No	No	No	No	No	No
	GAMMEX Non-Latex Sensitive Synthetic Sensoprene Surgical Glove	No	No	No	No	No	No
Medline Industries, Inc	DermAssure Green Powder-Free Neoprene Surgical Glove	No	No	No	No	No	No
Mölnlycke Health Care US LLC	Biogel NeoDerm Neoprene Surgical Glove	No	No	No	No	No	No

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

Dermatitis Group,¹⁹ the American Contact Dermatitis Society Core Allergen Series,²⁰ and the TRUE test (SmartPractice). Carba mix, however, was removed from the European Baseline Series in 1989 because of reported concomitant reactions with thiurams.²¹ Thiurams themselves were felt to be a sufficient screening allergen for carbamates because thiurams are oxidized carbamates and cross-reactivity was reported to occur between the 2 compounds.²² Further studies are necessary to assess the utility of using thiurams as a screening agent for carbamates, but given the high prevalence

of carbamates in glove manufacturing and increasing rates of sensitization, reintroduction of carba mix into the European series may be warranted.

Diphenylguanidine

1,3-Diphenylguanidine is not a carbamate, despite its inclusion in carba mix.⁸ Diphenylguanidine was specifically listed in a minority of gloves—only 9.5%. Thus, in patients who have positive patch

TABLE 10. Accelerators Used in PVC Patient Examination Gloves

PVC Exam Gloves							
Company	Product	TH	CM	MB	MM	DT	DPG
Adenna	VPF Vinyl Powder Free	No	No	No	No	No	No
	VITEX Vinyl Powder Free	No	No	No	No	No	No
Ansell Healthcare LLC	MICRO-TOUCH Elite	No	No	No	No	No	No
	Microflex Derm Free DF-850	No	No	No	No	No	No
Medline Industries, Inc	Accutouch Synthetic Exam Gloves	No	No	No	No	No	No
	Aloetouch 3G Powder-Free Synthetic Exam Gloves	No	No	No	No	No	No
	Aloetouch Ultra IC Powder-Free Synthetic Exam Gloves	No	No	No	No	No	No
	Cedar Vinyl Synthetic Exam Gloves	No	No	No	No	No	No
	CURAD Powder-Free Latex-Free 3G Vinyl Exam Gloves	No	No	No	No	No	No
	CURAD Stretch Vinyl Exam Gloves	No	No	No	No	No	No
	Designer Boxed Vinyl Exam Gloves	No	No	No	No	No	No
	FitGuard Stretch Vinyl Exam Gloves	No	No	No	No	No	No
	Generation Pink 3G Synthetic Exam Gloves	No	No	No	No	No	No
	Glide-On Powder-Free Vinyl Exam Gloves	No	No	No	No	No	No
	MediGuard Synthetic Exam Gloves	No	No	No	No	No	No
	MediGuard Vinyl Synthetic Exam Gloves	No	No	No	No	No	No
	Pro-Vision Select Powder-Free Exam Gloves	No	No	No	No	No	No
	SensiCare Powder-Free Stretch Vinyl Sterile Exam Gloves	No	No	No	No	No	No
	Ultra Stretch Synthetic Exam Gloves	No	No	No	No	No	No
Sempermed USA, Inc	Best Touch Vinyl	No	No	No	No	No	No
	SemperCare Vinyl	No	No	No	No	No	No
	Sempermed Synthetic Vinyl	No	No	No	No	No	No
SmartPractice	QualiTouch FlexTec Vinyl PF Natural	No	No	No	No	No	No
	Smart Touch Vinyl PF	No	No	No	No	No	No
	Dexterity Poly Vinyl PWD	No	No	No	No	No	No
	Dexterity Vinyl PF Fitted	No	No	No	No	No	No
	QualiTouch Xlong Cuff Vinyl PF	No	No	No	No	No	No

CM indicates carbamates; DP, diphenylthiourea; Unknown, representative was unsure about accelerator presence.

tests to carba mix, it may be preferable to additionally test to DPG separately because this may help isolate the true allergen and present patients with additional safe glove options.

Mercaptobenzothiazole/MM

Mercaptobenzothiazole is an accelerant used in the production of latex, as well as natural and synthetic rubber gloves.²³ It was a present in 19.5% of gloves reported in our series. Patients suspected of having glove dermatitis thus should undergo testing to MB. Mercaptobenzothiazole may not be stable when tested with the other constituents of MM: *N*-cyclohexyl-2-benzothiazyl sulfonamide, dibenzothiazyl disulfide, and morpholinyl MB; thus, testing should be performed with 3-component MM and MB separately.⁸

Dialkyl Thioureas

The thioureas (diethylthiourea, dibutylthiourea, diphenylthiourea, and thiourea) are used predominantly in the production of the synthetic rubber chloroprene (neoprene) and some foam rubbers.^{8,24} Among health care workers with occupational dermatitis, 1% tested positive to one of the thioureas.¹⁶ Of the 14 polychloroprene gloves—including 4 accelerator-free gloves—only 2 were reported to use DT; however, overall, 17 gloves (8.9%) reported using a diphenyl thiourea as an accelerant. Thus, although the thioureas are thought to play only a minor role in rubber glove allergy,¹⁷ they should not be disregarded.

Glove Alternatives

Finding a safe glove for patients who test positive to 1 or more of the accelerants is important not only to help them clear their dermatitis but also often to maintain employment. Medical gloves are considered medical devices and are regulated by the US Food and Drug Administration under the Medical Device Amendments of 1976, which amended the previous Federal Food, Drug, and Cosmetic Act.²⁵ The US Food and Drug Administration separates medical gloves into 2 broad categories: surgical gloves and medical examination gloves. Medical examination gloves may be made of latex, vinyl (polyvinyl chloride or PVC), and polymers other than vinyl such as rubber derivatives (nitrile, polyurethane, guayule rubber, polychloroprene [neoprene]).²⁶ Thus, for patients who work primarily in the outpatient setting, glove substitutions are easier, because the vinyl (PVC) gloves are safe alternatives as they are plastic based and do not use rubber accelerators in their manufacturing. However, the texture and limited dexterity afforded with vinyl gloves are off-putting to many workers. We contacted 8 manufacturers offering PVC examination gloves and confirmed that none were made with the use of accelerators; however, of those 8 companies, we were able to publish data from 5 (Table 10). In contrast, surgical gloves may be made only from natural or synthetic rubber, which makes finding a safe glove substitute difficult in light of a rubber accelerant allergy.

Fortunately, manufacturers have begun to make several rubber accelerator-free gloves for both medical examination and surgery

applications. In our series, 12 gloves were marketed as being accelerator free: 8 medical examination and 4 surgical gloves. However, the exact components of these gloves remain unknown, and whether these gloves truly are free of accelerators or new innovative accelerators are being used (which may have a sensitizing potential) has yet to be determined. In addition, gloves derived from thermoplastic elastomers, which circumvent the vulcanization process, may be another glove option; however, thermoplastic elastomer options are few and are limited in their dexterity, and during our search, we did not encounter any gloves claiming to be composed of this material from major manufacturers.

STRENGTHS AND LIMITATIONS

This study is important for several reasons: first, it corroborates other studies that have shown a general trend away from the use of thiurams and toward carbamates in the production of medical gloves. Second, it shows that several manufacturers are moving away from the use of classic accelerators to gloves touted to be accelerator free. Third, this study contributes important information to help clinicians provide their rubber-accelerant-allergic patients with safe alternatives.

There are several limitations associated with this study. First, several companies were reticent to disclose information pertaining toward the accelerators used, citing that it was “proprietary.” However, these companies noted that they would readily provide MSDS on a case-by-case basis. Another limitation of this project involved the identification of large-scale glove manufacturers. Because there are a multitude of medical-grade glove companies, it was difficult to ascertain all of the major players in this market. From 1985 to 1996, 454 licenses were granted for glove production in Malaysia, leading to dilution of the market.²⁷ Furthermore, manufacturers are continuously updating or changing product lines. During the course of this study, 1 manufacturer went from offering a number of medical examination gloves to offering zero. Thus, the information provided within this document is comprehensive but not exhaustive in terms of potential product offerings in the setting of a dynamic market.

CONCLUSIONS

Rubber accelerators are a common component in the production of medical examination and surgical gloves. Notably, carbamates were present in almost all the gloves listed, whereas MB and 1,3-DPG were present in a significant minority. Only 11 gloves used thiurams as the accelerant. As manufacturers become cognizant of the risk of sensitization, they are increasingly offering rubber-based gloves purported to be made without the use of accelerators.

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