OPEN ACCESS
Freely Available Online

INTERNATIONAL JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE
ISSN NO: 2690-0904

Research

DOI : 10.14302/issn.2690-0904.ijoe-19-2985

In Vivo Evaluation of the Protective Capacity of Different Gloves Against Hair Dyes

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Abstract

Hairdressers are taught to use gloves when dyeing hair. We wanted to study what gloves are recommendable for other common hair dye substances than *p*-phenylenediamine, such as toluene-2,5-diamine sulphate and 2-methoxymethyl-*p*-phenylenediamine. The gloves used in professional salons and the gloves commonly sold with hair dyes for home-use were investigated. 7 volunteers previously allergic to toluene-2,5-diamine sulphate and *p*-phenylenediamine were tested *in vivo* with an open chamber test system to examine the permeation of chemicals through gloves (vinyl, nitrile and polyethylene), mimicking the real use condition of permanent hair dyes. The nitrile gloves used gave excellent protection with all four hair dyes tested. A good capacity of protection was found with the polyethylene glove, supplied with the package of a home-use hair dye, when tested with the same hair dye. The advice to hairdressers is to choice nitrile gloves when using the permanent hair dyes currently available on the market.

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Keywords: oxidative hair dyes, hairdressers, contact allergy, protective gloves, hand eczema, p-phenylenediamine, 2-methoxymethyl-p-phenylenediamine, toluene-2,5-diamine sulphate, nitrile, vinyl

Received: Jul 30, 2019 **Accepted:** Aug 28, 2019 **Published:** Aug 29, 2019

Editor: Sabina Irimie, University of Petrosani, Romania.

Introduction

Hair dresser is a risk occupation due to wet-work and exposure to a multitude of chemical substances giving rise to both irritant and possible allergic contact dermatitis. Already during education, protective measures are taught. Even so, hairdressers run a high risk of occupational hand dermatitis and it is important that advice given by occupational dermatologists are accurate with regard to the hairdressers' actual work exposure and preventive measures. Studies have shown that educational programmes aiming at minimizing wet-work, learning correct use of gloves and acquiring knowledge on correct skin care, actually improve working conditions [1, 2]. However, a recent report has shown that, despite educational programs, hairdresser apprentices are still at increased risk of acquiring hand eczema [3]. Furthermore the hairdressers seem to acquire hand dermatitis after only a few years work. According to Lysdal et al. [4], in Denmark hairdressers remain in the profession on average for 8.4 years and where hand dermatitis is a common reason for leaving the trade [4].

Gloves are usually evaluated with regard to the protective quality in *in vitro* studies [5]. However the hairdressers wear the gloves in their daily work, the glove is exposed to wear and tear, water and a multitude of chemicals. A more realistic evaluation of skin protection provided by a glove would be achieved by performing *in vivo* provocation tests with commonly used hair dyes, comparing different glove materials. In a previous *in vivo* study [6] we have shown that with regard to hair-colouring products containing *p*-phenylenediamine (PPD) the nitrile glove was superior. In this study we wanted to test the protective effect of gloves further since not only PPD is used as hair colouring substance and hair dyeing also is performed at home where exposure conditions and glove recommendations may be different.

Aims of the Study

We wanted to verify the protective capacity of both nitrile and polyvinyl chloride gloves against hair dyes containing PPD, and investigate the capacity when exposed to hair dyes containing toluene-2,5-diamine sulphate (2,5-TDA-S) and 2-methoxymethyl-p-phenylenediamine (ME-PPD). Moreover, the protective effect of the gloves supplied in the package of an hair dye intended for home-use and containing 2,5-TDA-S, was evaluated with the same hair dye. These gloves according to the manufacturer of the hair dye for home use were considered to be "suitable material" (in general polyethylene or polyvinyl chloride).

The aim was to ensure that the results were useful for the consumer/hairdresser by investigating commonly used products, both gloves and hair dyes, and simulating ordinary use. The choice of gloves to test were based on the previous study and visits to hairdressers' saloons, hairdressers' vocational schools and retail shops for hairdressers, in order to find which groups of gloves were most commonly bought by hair care professionals in Malmö.

The selection of hair dyes used were based on results from previous studies with regard to exposure [6, 7]. Efforts were made to find hair dyes where the colouring substance was in the higher allowed concentration range.

Materials & Methods

Subjects

Seven volunteers (6 females and 1 male, age 19-60 years, median age 27 years) were enrolled in the study. They had been previously tested with 2,5-TDA-S 1% in petrolatum (pet.) and PPD 1% in pet. at the Department of Occupational and Environmental Dermatology (DOED) in Malmö, and presented with a ++ or +++ reactions according to the International Contact Dermatitis Research Group (ICDRG) criteria [8,9]. Exclusion criteria were sensitization to fragrances and rubber derivatives. The participants were recruited by phone call. The subjects were sent written detailed information on the study before inclusion.

Gloves

Two nitrile gloves of different brands and one vinyl glove were investigated (Table I). The gloves provided in the package of the at-home hair dye were investigated with the same dye in all the 7 volunteers and in 5 of them also using 3 professional hair dyes. As negative control the 4H®-glove (made of layers of polyethylene/ethylene-vinyl-alcohol laminate) (North Safety Products by Honeywell, Smithfield, USA) with known protective ability against chemicals [10], was

Table 1. List of gloves tested.

Gloves, Manufacturer	Material	Thickness (mm) Measured [a]	Source of selection
Semperguard®, Semperit	Nitrile	0,08	hairdresser in Malmö
Papyrus supplies vinyl powdered®, Papyrus Supplies	Polyvinyl chloride	0,10	hairdresser in Malmö
Papyrus supplies nitrile indigo fine®, Papyrus Supplies	Nitrile	0,13	hairdresser in Malmö
Plastic gloves contained in Schwarz-kopf hair dye (Natural & Easy 590®)	Polyethylene[b]	0,03	contained in Schwarzkopf hair dye for home use
4H® silver shield, North by Honeywell	EVOH/PE laminate	0,08	used in the chemical industry

a: mean value of 3 measurements

b: according to our analysis with FTIR

Thickness on palm/back of the gloves measured at our laboratory. The material of the gloves provided with the at-home dye was analysed with Fourier Transform Infrared (FTIR) spectrometry.

used.

Hair dyes

Three permanent hair dyes (Table II) intended for professional use (HDp), 1 containing PPD (HDp-PPD), 1 containing 2,5 TDA sulphate (HDp-TDA-S), 1 containing ME-PPD (HDp-ME-PPD), and 1 hair dye for home use (HDhu) and containing 2,5-TDA-S (HDhu-TDA-S), were used. The hair dyes tested were prepared, simulating their ordinary use, by mixing the colouring cream with the corresponding developer containing hydrogen peroxide 3% (10 vol.) or 6% (20 vol.) with a mixing ratio of 1:1 w:w, immediately before the application in the test chambers system.

Gloves Analysis

Fourier-transform infrared (FTIR) spectroscopy was performed with an Agilent Cary 630 FTIR spectrometer (Agilent Technologies, Danbury, CT, USA) was used to analyse the material of the gloves supplied with the hair dye for the home use and labelled as "plastic" on the package leaflets. The method compared the spectrum of the analysed material with a database of the spectra of a wide range of materials. The thickness of gloves was measured at the palm/back of three samples for each glove by using a micrometer screw-gauge (Table 1).

Chemical Investigation of Hair Dyes

High performance liquid chromatography (HPLC) analysis of the hair dyes was performed according to the method described by Antelmi et al. in 2016 [10], detecting the PPD and 2,5-TDA content in all the colouring creams (before adding hydrogen peroxide) (Table II). The analysis with regard to PPD and 2,5-TDA content was performed also in the ME-PPD-containing hair dye, the two chemicals were not detected given the quantification limit of 0.05% w/w. The ME-PPD content of the hair dye was not analysed since the reference substance could not be purchased at the time.

Exposure Time

The exposure time for the provocation test was chosen based on information acquired in workplace visits to hairdressers' saloons in Malmö. A maximum time of 45 minutes wearing gloves was thought appropriate. With regard to the at-home kit to dye hair, the instructions for use provided by the leaflet of the hair dye were used and 30 minutes was estimated as exposure time while wearing the gloves provided in the package, considering 5-10 minutes for the colouring procedure at-home and 5-20 minutes for the following wash of the newly dyed hair (no more than one pair of gloves is offered in each package).

Patch Test

To establish the current reactivity of the volunteers, a dilution series of PPD in ethanol (w/v) and 2,5-TDA-S in pet. (w/w) (1.0%, 0.1%, 0.01%, 0.001%, 0.0001%) were patch tested. For those with a previous +++ reaction to PPD and/or 2,5-TDA-S, the highest concentration tested was fixed at 10 times less than the threshold of reactivity previously observed in each subject. Finn Chambers® (Ø8 mm) (Smart Practice, Phoenix, AZ, USA) on Scanpor® tape (Norgesplaster A/S Vennesla, Norway) were used for patch testing the dilution series. 15 µl of test solution, applied with a micropipette, for the PPD dilution series and 20 mg of pet. for the 2,5-TDA-S dilution series respectively were applied in each test chamber. The chambers were put on the back of the patients at the same time as the *in vivo* study and left for 2 days (48 hours), the reading was performed at day 4 (D4) and D7. The reactions were scored according to the ICDRG criteria [8, 9].

In Vivo "Provocation Test"

The *in vivo* provocation test was carried out with an open chamber test system (Figure 1) developed at the DOED in Malmö to evaluate *in vivo* the permeation through gloves of different chemicals [6, 10]. The procedure of testing has been described elsewhere [6, 10]. During the provocation the subject lies in the supine position exposing the back. The chambers with the substance to be tested are applied to the back for fixed periods of time. The procedure is carried out with standardised humidity and temperature. The chambers are prepared with the glove material to be tested fixed with metal clips the bottom of the chamber ie where the chamber is fixed to the skin of back, thus acting as a membrane between hairdye and skin, simulating the actual effect of a glove in the same material (Fig 1,2).

In the study, the hair dye mixtures (prepared to simulate ordinary use, see above) was prepared within 4 minutes prior to the application. The professional hair dyes were tested with the three gloves (2 nitrile, 1 polyvinyl chloride), a negative control consisting of 4H® glove, and a positive control consisting of a chamber devoid of glove on the bottom, filled with the hair dye directly in contact with the skin. The exposure time chosen was 45 minutes. For the home-use hair dye the polyethylene glove supplied in the package was tested at the exposure time of 30 minutes. The chambers were filled until half height (approximately 6 mm) with the hair dye/peroxide mixture (Figure 2) after removal of the test devices, a clinical examination of the skin corresponding to the test application area, was performed to detect the presence of dark spots as visible signs of permeation through the gloves. The integrity of glove material tested and the possible presence of breakages were verified by cleansing the glove material and through visual examination. Readings were performed of the areas according to the ICDRG guidelines on D4 and D7 [8, 9]. The test procedures and test readings were photo-documented.

Ethics

The subjects gave informed consent and the Regional Ethical Review Board in Lund, Sweden, approved the protocol. The study was conducted in accordance with ethical standards on human experimentation and with the Helsinki Declaration of 1975, as revised in 1983.

Statistics

McNemar's test two-sided was used for pair-wise comparison of the protective effect of the four gloves (2 nitrile, 1 polyvinyl chloride, 1 polyethylene) and of the test performed without the glove as membrane between the chambers/hair dyes and the skin (positive control). One-sided McNemar's test was used to compare the protective effect of each glove and the positive control, versus the 4H® glove (negative control). A *p*-value below 0.05 was considered significant. For the same glove pair-wise comparisons using Fisher's test were made to compare the protective effects against the four hair dyes.

Results

The gloves supplied in the hair dye for home use was analysed with Agilent Cary 630 FTIR spectrometer and it was found that the material was polyethylene. The average thickness of the gloves measured with a micrometer screw-gauge was within a range of 0.03- 0.13 mm (Table I).

All the volunteers were tested with the open chamber test without any glove membrane (positive control) for 45 min of exposure with the 3 HDp, (HDp-TDA-S, HDp-PPD, HDp-ME-PPD) and for 30 min with the HDhu-TDA-S and all developed positive reactions except for two who did not react to the test

Table 2. Hair dyes tested and their concentration (%) of of p-phenylenediamine (PPD) and toluene-2,5-diamine (2,5-TDA) analysed with high performance liquid chromatography (HPLC).

Hair dyes	PPD (%)	2,5-TDA (%)
Koleston Perfect Wella® Black 2/0 HDp-TDA-S	ND	0.86
Infiniti Affinage® Black 1.0 HDp-PPD	0.9	ND
Koleston Perfekt Innosense Wella® 2.0 HDp-ME-PPD	ND	ND
Natur & Easy Schwarzkopf® 590 svart HDhu-TDA-S	ND	0.68

The hair dyes collected were intended for professional use (HDp) and for home use (HDhu). One hair dye for professional use contained 2-methoxymethyl-p-phenylenediamine (ME-PPD). The mixture colouring cream-developer with a 1:1 mixing ratio according to the instructions was analysed for each hair dye. Concentrations below the quantification limit of 0.05 were considered not detectable (ND).

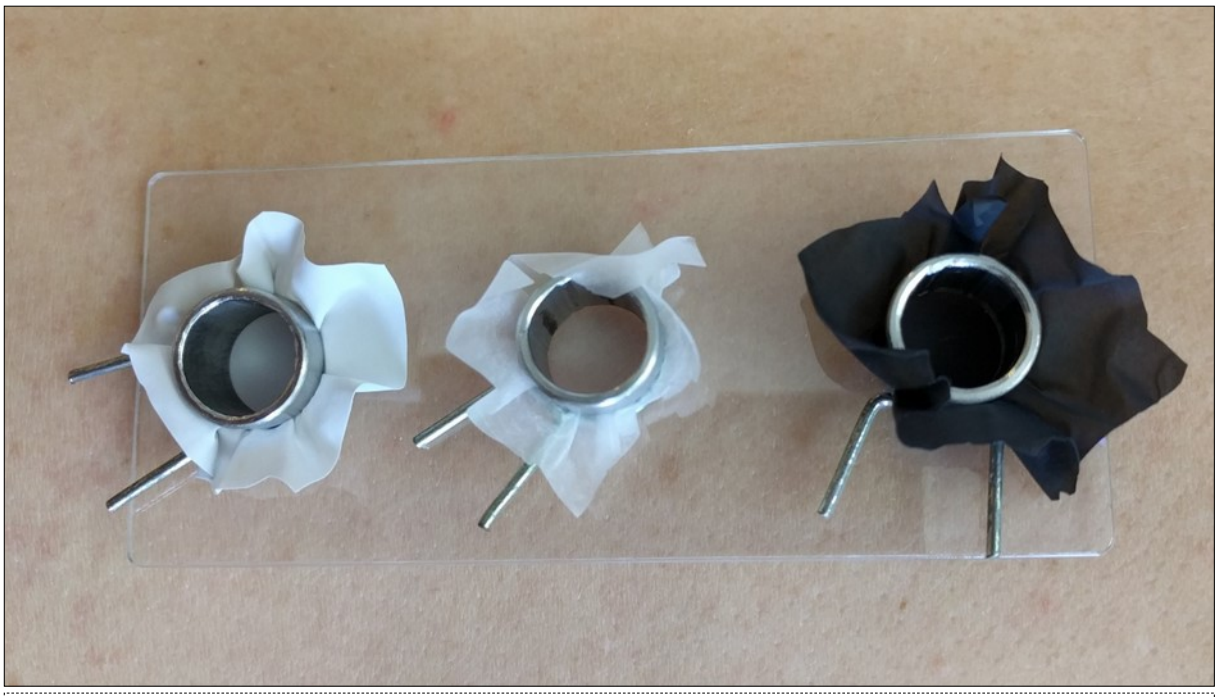

Figure 1. The "open chamber" test device. 1 mm thick transparent and flexible acrylic support with three circular spaces for fitting in three circular chambers made of chemical-resistant stainless-steel. Rectangular pieces of glove were fixed with a nickel-free metallic clip to the chambers, thus constituting the bottom of the chamber. The chambers were filled with the oxidative hair dyes.

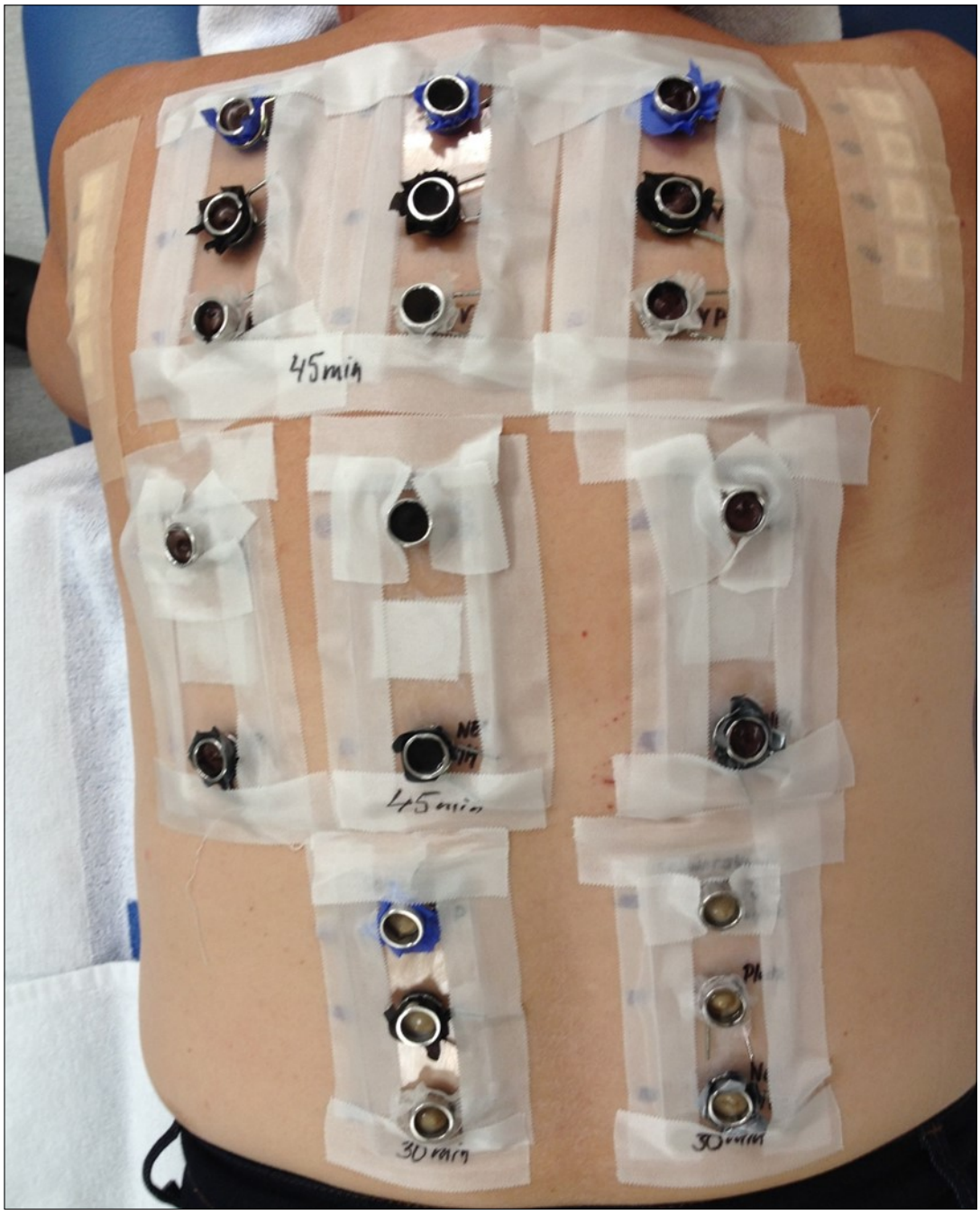

Figure 2. The test device after the application on the back. The chambers were filled with three hair dyes for professional use tested for 45 minutes and on hair dye for home-use tested at 30 minutes.

with HDp-ME-PPD (Figure 3, Table 3).

With the open chamber test with the 4H® glove (negative control) and when the 4 hair dyes were tested with the 2 nitrile gloves there were no positive.

The polyvinyl chloride glove did not give any protection in 6 volunteers when used with the hair dye HDp-TDA-S, and neither in 5 volunteers when used with HDp-PPD and HDhu-TDA- S. Regarding the hair dye HDp-ME-PPD however no reactions were noted with the polyvinyl chloride glove (Table III). Statistically, the 4H® glove gave better protection than the polyvinyl chloride glove for all hair dyes except HDp-ME-PPD (Table IV). There was no difference between the nitrile gloves and 4H®. The 2 nitrile gloves gave b etter protection than the polyvinyl chloride against the HDp-TDA-S in 6 subject, results being statistically significant (p= 0.031); between the HDp-PPD and the HDhu-TDA-S the difference was not significant however with a result close to statistically so (p=0.062). No difference in term of reactions detected on the skin at test reading 1 (D4) and 2 (D7) was found between the nitrile and polyvinyl chloride gloves tested with HDp-ME-PPD.

The polyethylene glove protected all 7 tested individuals exposed for 30 min to the HDhu-TDA-S, and all the 5 individuals tested with HDp-ME-PPD for 45 min. With this longer exposure time, there was no protection obtained neither with the polyethylene glove concerning 4 of the 5 tested individuals with HDp-TDA-S nor for 2 of the 5 volunteers tested with HDp-PPD (Table III). Comparing the negative control with the polyethylene glove concerning the protection against the HDp-TDA-S, a statistical significance was indicated (p= 0.062) (Table IV). The 4H® glove and the polyethylene glove gave the same protection with HDhu-TDA-S.

When tested with the HDhu-TDA-S hair dye for 30 minutes, the protection of polyvinyl chloride was adequate only for 2 subjects of 7. In the small group of 5 subjects tested with the polyethylene gloves and professional hair dyes at 45 minutes, results were not statistically significant but the trend comparing polyethylene and polyvinyl chloride gloves was the same

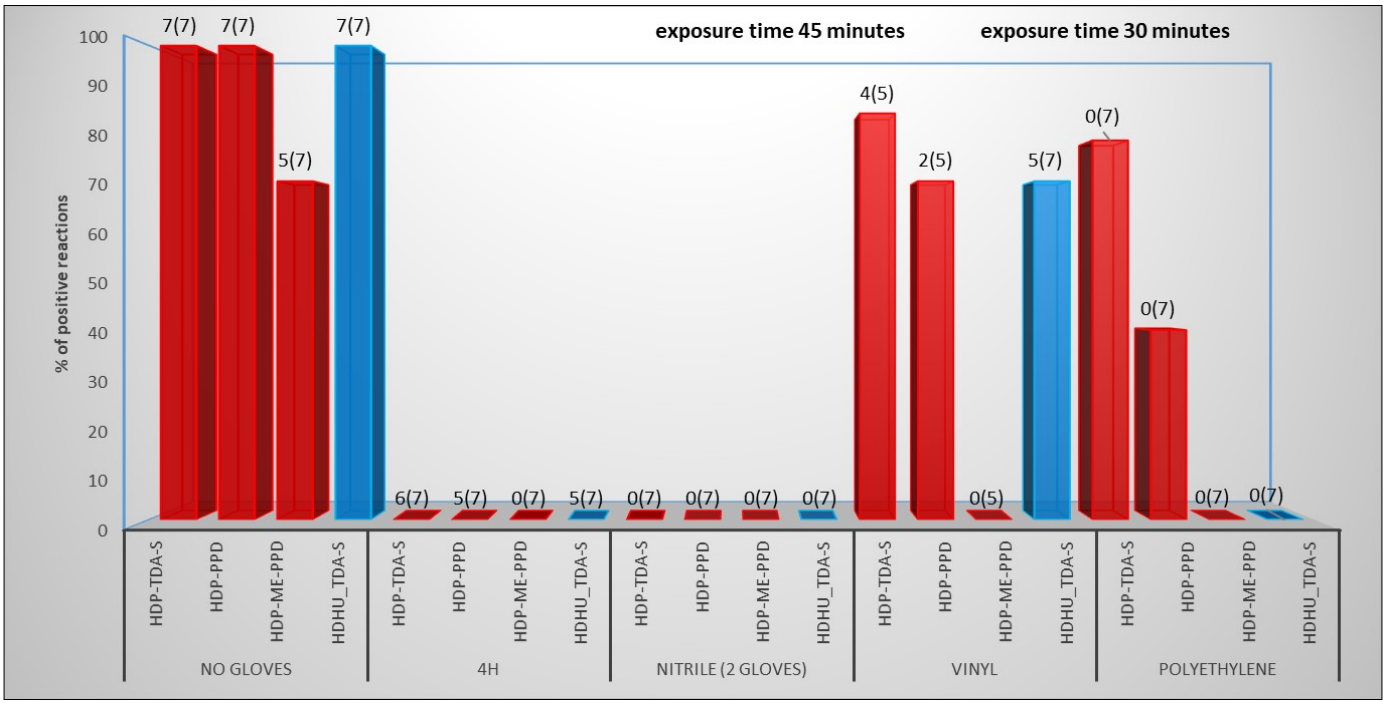

Figure 3. Percentage of positive reactions testing 4 hair dyes with different gloves.
Percentage of positive reactions observed testing the various glove materials with the three professional hair dyes (HDp) and with the home-use hair dye (HDhu) through the open chambers testing system. The hair dyes were encoded according to the colouring ingredients (TDA=toluene-2,5-diamine sulfate, PPD= p-phenylenediamine, ME-PPD=2-methoxymethyl-p-phenylenediamine). The number on the top of the column indicate the number of positive reactions on the total number volunteers tested. Two exposure time of 30 minutes was used to test the HDhu-TDA with the various gloves. The polyhethylene glove was tested with professional hair dyes in 5 of the 7 subjects enrolled.

Table 3. Results of patch testing with serial dilutions of p-phenylenediamine (PPD) and toluene-2,5-diamine sulphate (2,5-TDA-S) as well as reactions of the open provocation test with 4 hair dyes and 5 gloves in 7 subjects with contact allergy to PPD and 2,5-TDA. The exposure time was 45 minutes for professional hair dyes (HDp) and 30 minutes for the hair dye for home-use (HDhu). The test reading was performed on day 4 (D4). One hair dye for professional use contained 2-methoxymethyl-p-phenylenediamine (ME-PPD).

+,++,+++ = positive reactions of various intensities; - = negative reaction; NT = not tested; *indicates a negative reaction on D4 but positive on D7

	PPD ethanol % w/v					2,5-TDA sulphate vas % w/v					hair colouring sub-stance contained in the hair dyes (HD)	Gloves tested				
Subjects (no=number)	1	0.1	0.01	0.01	0.001	1	0.1	0.01	0.001	0.001		Nitrile Papyrus	Nitrile Semperguard	Polyvinyl chloride Papyrus	Polyethylene (Schwartzkopf N&E)	Positive control/ no glove	Negative control/4H® glove
no.1	NT	++	-	-	-	++	++	-	-	-	HDp-TDA HDp-PPD HDp-ME-PPD HDhu-TDA	- - - -	- - - -	+ ++ - +*	NT NT NT -	+++ +++ + +++	- - - -
no.2	NT	-	-	-	-	++	+	-	-	-	HDp-TDA HDp-PPD HDp-ME-PPD HDhu-TDA	- - - -	- - - -	++ - - ++	NT NT NT -	++ ++ + ++	- - - -
no.3	NT	++	-	-	-	NT	+	-	-	-	HDp-TDA HDp-PPD HDp-ME-PPD HDhu-TDA	- - - -	- - - -	++ ++ - -	++ ++ - -	+++ +++ ++ +++	- - - -
no.4	++	-	-	-	-	++	-	-	-	-	HDp-TDA HDp-PPD HDp-ME-PPD HDhu-TDA	- - - -	- - - -	- + - +	- - - -	++ +++ - ++	- - - -
no.5	NT	++	+	-	-	NT	++	-	-	-	HDp-TDA HDp-PPD HDp-ME-PPD HDhu-TDA	- - - -	- - - -	++ + - +	+ - - -	+++ +++ ++ +++	- - - -
no.6	NT	+	-	-	-	++	+	-	-	-	HDp-TDA HDp-PPD HDp-ME-PPD HDhu-TDA	- - - -	- - - -	+ - - -	++ - - -	+++ + - +++	- - - -
no.7	NT	+++	-	-	-	++	++	-	-	-	HDp-TDA HDp-PPD HDp-ME-PPD HDhu-TDA	- - - -	- - - -	++ ++ - ++	++ ++ - -	+++ +++ ++ +++	- - - -

Table 4. Results of the statistical analysis (p-value calculated) comparing the protective performance of different glove materials. p-values calculated with pair-wise comparisons of protective capacity between the five gloves using the McNemar´s test two-sided. Pair-wise comparison between 4H® and each glove tested with hair dyes, calculated with McNemar´s test one-sided. Values highlighted in bold when statistical significance demonstrated ($p<0.05$), in it is indicated ($p=0.062$).Abbreviations: hair dye for professional use (HDp), hair dye for home use (HDhu), 2-methoxymethyl-p-phenylenediamine (ME-PPD), p-phenylenediamine (PPD), and toluene-2,5-diamine sulphate (2,5-T DA-S).

			Nitrile				**Polyvinyl chloride**				**Polyethylene**				**4H®**				**No gloves**			
			HDp			HDhu-TDA-S	HDp			HDhu-TDA-S	HDp			HDhu-TDA-S	HDp			HDhu-TDA-S	HDp			HDhu-TDA-S
			TDA-S	PPD	ME-PPD		TDA-S	PPD	ME-PPD		TDA-S	PPD	ME-PPD		TDA-S	PPD	ME-PPD		TDA-S	PPD	ME-PPD	
Nitrile	HDp	TDA-S	-				**0.031**				0.125				-				**0.015**			
		PPD		-				*0.062*				>0.3				-				**0.015**		
		ME-PPD			-				-				-				-				*0.062*	
	HDhu-TDA-S					-				*0.062*				-				-				**0.015**
Polyvinyl chloride	HDp	TDA-S	**0.031**				-				-				**0.015**				>0.3			
		PPD		*0.062*				-				>0,3				**0.031**				>0.3		
		ME-PPD			-				-				-				-				*0.062*	
	HDhu-TDA-S					*0.062*				-				0.25				**0.031**				>0.5
Polyeth-ylene	HDp	TDA-S	0.125				-				-				*0.062*				>0.3			
		PPD		>0.3				>0.3				-				0.124				0.25		
		ME-PPD			-				-				-				-				0.25	
	HDhu-TDA-S					-				>0.3				-				-				**0.015**
4H®	HDp	TDA-S	-				**0.015**				*0.062*				-				**0.007**			
		PPD		-				**0.031**				0.124				-				**0.007**		
		ME-PPD			-				-				-				-				*0.062*	
	HDhu-TDA-S					-				**0.031**				-				-				**0.007**
No gloves	HDp	TDA-S	**0.015**				>0.3				>0.3					**0.007**						
		PPD		**0.015**				>0.3				0.25					**0.007**			-		
		ME-PPD			*0.062*				*0.062*				0.25					*0.062*			-	
	HDhu-TDA-S					**0.015**				>0.3				**0.015**					**0.007**			-

when they were tested with HDp-ME-PPD and with HDp-TDA-S (Table III).

Thus, the 4H® and nitrile gloves gave complete protection regardless of what hair dye was used. For the polyethylene and polyvinyl chloride gloves, respectively, complete protection was obtained against the HDp-ME-PPD but not against the other three hair dyes (Table III, Figure 3).

No association was found for the polyvinyl chloride glove concerning the individual degree of patch test reactivity to PPD and the protective capacity, whereas with regard to 2,5-TDA-S reactivity, a numerical but not statistical association was indicated.

Discussion

In a profession such as the hairdressers' where there is a huge exposure to both irritants and potentially contact allergic chemicals, the choice of gloves is of course important, and if advices can be based on evaluation simulating real life this is an obvious advantage. A method to evaluate the performance of glove material could thus be through *in vivo* studies mimicking the workplace exposure. In order to improve the advice given to hairdressers regarding protective gloves, we performed a study a few years ago [6] comparing the protective capacity of glove materials commonly used among hairdressers when exposed to a hair dye containing PPD. A good protection from nitrile gloves was noted. An interventional workplace-based study [11] concluded that when used correct, gloves can be protective in real work situations. Geens et al. [11] investigated the systemic exposure of hairdressers to 2,5-TDA-S and PPD using urine diamine biomarkers before and after ordinary work with permanent hair dyes the first week and again after providing nitrile gloves to hairdressers in the second week. Through the biomonitoring of PPD and 2,5-TDA-S a significant decrease of systemic exposure to 2,5-TDA-S but not to PPD was noted explained by the adequate use of nitrile gloves.

With regard to the exposure to hair dye ingredients, they vary qualitatively and quantitatively in different regions of the world. It is known that hair dyes in northern Europe more often contain 2,5-TDA or 2,5-TDA-S than PPD, or these dye ingredients combined [12-14]. Furthermore, products bought in non-European countries usually contain higher concentrations of PPD [12]. When comparing patch test results from dermatitis patients tested between 2003 and 2007 in 10 European patch test centres were compared, PPD sensitization occurred more often in Central and Southern Europe than in Scandinavia [15]. The difference was thought to be due to the use of hair dyes with a darker shades more frequently. Moreover, a new hair dye substance, ME-PPD, was recently introduced in Europe [16-18], with the aim to decrease the risk of sensitization and elicitation of allergic contact dermatitis.

In this study we wanted to further investigate the nitrile gloves that have already been found superior with regard to PPD [6] to evaluate them and other commonly used gloves for professional use and for home-dyeing, when using a PPD-, a 2,5-TDA-S- and a ME-PPD-containing hair dye for professional use and a 2,5-TDA-S-containing hair dye for home use. In order to get information on the hair dye products recommended for hairdressers during education and to collect information on how and to what degree protective measurements were taught, a visit in a school for apprentices hairdressers in Malmö was performed. Information on choice of gloves were collected also by performing a short interview with professional hairdressers, visiting 11 hairdressers' saloons in the city of Malmö. The information was used to improve the actual study with regard to material used and time of exposure. In the study, where the aim was to evaluate gloves and hair dyes, a fixed time was decided. According to the outcome of our preliminary investigation including both hairdresser apprentices and professional hairdressers, we evaluated that a maximum exposure of 45 minutes in professional use and 30 minutes in the at-home dye condition was plausible.

The performance of the polyethylene glove supplied in the package of a home-use hair dye was completely protective in all the subjects against the home-use hair dye, at 30 minutes of exposure, according to the instruction in the package. When the same glove was tested with professional hair dyes only (in 5 of the 7 individuals), its performance was poor most probably due to the increased exposure time (45 min).

Comparing the protection offered by the polyvinyl chloride gloves when using the different professional hair dyes, these gloves did not have a good

Figure 4. Positive reactions observed at day 4 (D4) in subject n.7.

Figure 5. Positive reactions observed at day 4 (D4) in subject n.3.

performance since 5 and 6 of 7 subjects reacted when tested with the HDp-PPD and with HDp-TDA-S respectively, and 5 of 7 subjects reacted at 30 minutes of exposure with HDhu-TDA-S.

With regard to polyvinyl chloride (tested in 7 subjects) and polyethylene (tested in 5 subjects) with the HDp-ME-PPD, excellent protection was shown. On the other hand considering that the hair dye containing ME-PPD has recently been introduced on the market, we do not really know which reactivity pattern patients primarily sensitized to the ME-PPD would have. Therefore a larger group of individuals should be tested to verify if the good protection provided by the gloves tested with this hair dye is due to a lower allergenic potential of the hair dye–ME-PPD-based. Previous patch testing with ME-PPD showed that there is decreased strength of elicitation response to this hair dye containing ME-PPD in PPD/TDA allergic subjects [17] and it has been shown that the hair dye products containing ME-PPD were tolerated by 29/43 PPD/TDA allergic individuals throughout continued hair dyeing with repeated treatments [18]. In our study we could not patch test with dilution series of the substance as such and thus we have no knowledge of the actual reactivity pattern with regard to ME-PPD. The two nitrile gloves gave complete protection with the three professional hair dyes at 45 minutes and with the home use hair dye at 30 minutes, comparable to the 4H® glove (Figure 3, Figure 4, 5), known to have excellent performance with regard to protection against chemicals [6, 10].

In term of advice to hairdressers the study has shown that the nitrile glove must be the preferred choice during the hair dye procedures with the permanent hair dyes currently available. Also with regard to ME-PPD, nitrile gloves is easiest to advice since we know that these will protect the consumer. However limited, the study indicates that the use of hair dye for home use the gloves supplied in the package can be considered safe in term of hand exposure during the at-home dyeing procedure, taken into consideration that the exposure time is limited to 30 minutes. Of course this does not prevent the at-home dye consumer or the person visiting the hairdresser from the risk of sensitization since the major risk is the actual hair dyeing in the individual case.

Acknowledgements

The authors wish to thank Ann-Charlotte Thorsson and Linda R. Ljungberg for skillful assistance during the study and Ewa Young for the participation to the conception of the study.

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