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Formaldehyde in reusable protective gloves

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Due to the clinical findings in a single patient's case, formaldehyde was suspected to be present in clinically relevant levels in reusable protective gloves. Therefore, 9 types of gloves were investigated with the semi-quantitative chromotropic acid method. It was found that 6/9 gloves emitted some formaldehyde and that 4/9 gloves emitted $\geq$40 μg of formaldehyde. Most of the formaldehyde was found on the inside of the gloves. To get an indication of the clinical relevance, a comparison with a protective cream declared to contain the formaldehyde-releasing agent diazolidinyl urea was performed by comparing areas of gloves with areas of cream layers with thickness 1–2 mg/cm^2. It was found that the amounts of formaldehyde emitted from the gloves might be in the same range as emitted from a layer of cream.

Key words: chromotropic acid method; contact allergy; formaldehyde; preservative; prevention; protective gloves. © 2006 The Author. Journal compilation © 2006 Blackwell Munksgaard.

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Protective gloves are often recommended in occupations that involve exposure to irritants and contact allergens. However, the occlusive effect of gloves can also influence the water barrier function negatively and enhance penetration of contact allergens (1–3). Thus, when patients are recommended to wear gloves, it is important that the advice given is optimized with regard to the individual patient's exposure and that the risk that the recommended gloves worsen or cause dermatitis is minimized.

Index Case

A man aged 23 working in a restaurant was referred due to hand dermatitis, which had started at work. It was localized to the dorsal aspects of the hands and volar aspects of the wrists. As a child, he had flexural dermatitis, which healed after a few years. He was patch-tested with the standard patch test series. The tests were applied for 48 hr and read on D3 and 7 and scored according to the criteria of the International Contact Dermatitis Research Group (ICDRG). He was found to have contact allergy to the formaldehyde releaser Quaternium 15 (++) and a doubtful reaction to formaldehyde 1% in water. When tested with 2% formaldehyde, he had a positive (++) reaction. To prevent the dermatitis, he was advised to wear the polyvinyl chloride (PVC) gloves provided at work more frequently, as he almost never protected his hands when in contact with fresh food and detergents. He had brought these gloves and was tested with the inside of the gloves as is and found to have a papular reaction, with a morphology suggesting contact allergy. 19 controls were tested with the inside of the glove, and 2 of these had doubtful (?) reactions. Because the patient was diagnosed with contact allergy to formaldehyde, the glove was analysed for emission of formaldehyde with the chromotropic acid (CA) method (4). 1 g of the glove emitted approximately 20 μg formaldehyde. To imitate the occlusive conditions, the same amount of glove material was moisturized with water. It was then found that it emitted approximately 40 μg formaldehyde.

Aim

It was suspected that this particular glove was not a single case but reflected a more widespread presence of formaldehyde in the same type of gloves, i.e. reusable protective gloves with a lining with flocked textile material. To get an indication of the occurrence of formaldehyde in this and similar types of gloves, a selection of reusable protective gloves with a lining with flocked textile material was bought and analysed with the CA method (4). Furthermore, the emission of

formaldehyde from the gloves was roughly compared to a protective cream declared to contain the formaldehyde-releasing preservative diazolidinyl urea (Germall II). To enable the comparison, areas of gloves were compared to areas of cream layer.

Materials and Methods

Gloves

Nine types of gloves were bought from 4 Swedish suppliers of protective equipment, including the supply depot of our hospital (Malmö University Hospital, Sweden). The materials of the gloves were declared to be PVC plastics, nitrile rubber and natural rubber latex (NRL). The gloves were (the glove material within brackets) Sempermed Industrial Sempersoft (PVC), Semperit Sempermed Industrial Semperplus (nitrile), Marigold Industrial Supasoft S20B (nitrile), Marigold Industrial G21B (nitrile), Handisafe Nordic AB, Ängelholm, Sweden; Ansell Econohands Plus (latex), Ansell Extra (latex), Profa Skyddsprodukter AB, Lund, Sweden; Ejendels Tegera 8180 (PVC), Ejendals Tegera 8170 (PVC), Ejendals AB, Landskrona, Sweden; Swehand Combex (PVC), Procurator AB, Malmö, Sweden. All investigated gloves were lined with flocked textile material. From each package of 144 pairs of gloves, 2 samples were randomly picked out, and from each glove, a 8×8 cm piece was cut out from the volar aspect of the wrist and the dorsal hand, respectively, a 6×7 cm piece from the middle finger (dig III), and a 4×4 cm piece from the forth finger (dig IV). To separate the analysis of the inside and outside of the glove, the middle fingers of a pair of gloves were used. One of the fingers was turned inside out and both fingers were then 'sealed' with a piece of wire shown not to emit formaldehyde. To imitate the occlusive effect of the glove against the skin, all samples were moisturized with 1 ml of water.

Cream

To roughly compare the emission of formaldehyde from the surface areas of the gloves and the cream declared to contain $<1\%$ diazolidinyl urea (DebbaDry, Deb Sverige AB, Hässleholm, Sweden), 1 mg/cm^2 and 2 mg/cm^2, respectively, was spread on 2 pieces of aluminium foil measuring 16×16 cm. The cream in question was also spread on 4 8×8 cm areas of normal skin on the legs of a test person and the amounts that felt comfortable but still gave a visible layer of cream were found to range from 1 mg/cm^2 to 2 mg/cm^2. Each 16×16 piece of foil with the cream layer was cut into pieces of each 8×8, 4×8, 4×4, 2×4 and 2×2 cm, and the emission of formaldehyde from each piece was investigated, as well as the emission from 0.5 g of cream.

Chemical analysis

The analysis of formaldehyde was performed with the CA method (4). It is a relatively easily performed semi-quantitative method based on the reaction of formaldehyde with CA. The glove samples, aluminium foils with cream, 1.0 ml of the standard solutions, and a blank (1.0 ml of purified water) were put in 25-ml glass jars with ground-in stoppers. In the present study, standard solutions containing 2.5 μg, 5 μg, 10 μg, 30 μg, 40 μg and 60 μg of formaldehyde/ml were used. In each glass jar with a glove sample, an aluminium foil with cream, standard solution or blank was placed a 1.0-ml glass tube with 0.5 ml of the freshly prepared reagent (CA in concentrated sulfuric acid, 4 mg/ml). The analysis was performed after 2 days, during which time all jars were kept in dark.

When a violet colour appeared in the sample, it was visually compared to the standard solutions and the amount of formaldehyde thus approximately estimated. Sometimes discolourations may occur but in the present study the analysis was not disturbed by any discolouration.

Results

The emission of formaldehyde from the 9 gloves is given in Table 1. It was found that 6/9 (67%) of the investigated gloves emitted some formaldehyde and that 4/9 (44%) emitted ≥ 40 μg formaldehyde from the 8×8 cm pieces. When the inside and outside of the glove fingers were investigated separately, it was shown that the insides generally emitted most formaldehyde (Table 2).

0.5 g of the cream emitted >60 μg formaldehyde. The amounts of formaldehyde detected in the cream spread on the pieces of aluminium foils are given in Table 3. It can be noted that a thinner layer of cream tends to emit less formaldehyde than thicker layers, even if the total amount of cream is the same. The pieces of foil with the thicker layer (2 mg/cm^2) of cream emit amounts of formaldehyde in approximately the same range as the gloves containing most formaldehyde, while the pieces of aluminium foil with the thinner layer (1 mg/cm^2) of cream in the majority of cases emit less formaldehyde than the corresponding areas of the gloves containing most formaldehyde.

Table 1. Formaldehyde content (μg) in reusable protective gloves with flocked lining[a]

		Volar wrist 8 × 8		Dorsal hand 8 × 8		Dig III 6 × 7		Dig IV 4 × 4	
Glove/glove pieces (cm)	Material	A	B	A	B	A	B	A	B
Sempersoft	PVC	40	30	60	60	60	60	40	30
Supasoft S20B	nitrile	60	60	60	60	60	60	30	40
Tegera 8180	PVC	10	10	20	20	10	20	5	10
Tegera 8170	PVC	20	20	20	20	20	10	5	10
Swehand Combex	PVC	40	60	60	30	40	30	20	30
Extra	NRL	40	40	40	40	30	30	10	20
G21B	nitrile	–	–	–	–	–	–	–	–
Semperplus	nitrile	–	–	–	–	–	–	–	–
Econohands plus	NRL	–	–	–	–	–	–	–	–

–, not detected; A, B, 2 random samples from 144 pairs of gloves; NRL, natural rubber latex; PVC, polyvinyl chloride.
[a]The formaldehyde content (μg) was analysed with the chromotropic acid method using standard solutions containing 2.5 μg, 5 μg, 10 μg, 30 μg, 40 μg and 60 μg of formaldehyde. The content of formaldehyde was estimated by visually comparing the intensity of the violet colour of the reagent in the samples with the colour of the reagent in the standard solutions.

Table 2. Formaldehyde content (μg) in reusable protective gloves with flocked lining (inside and outside)[a]

Glove	Inside dig III	Outside dig III
Sempersoft	60	5
Supasoft S20B	40	5
Tegera 8180	10	2.5
Tegera 8170	10	2.5
Swehand Combex	30	2.5
Extra	20	2

[a]The formaldehyde content (μg) was analysed with the chromotropic acid method using standard solutions containing 2.5 μg, 5 μg, 10 μg, 30 μg, 40 μg and 60 μg of formaldehyde. The content of formaldehyde was estimated by visually comparing the intensity of the violet colour of the reagent in the samples with the colour of the reagent in the standard solutions.

Table 3. Formaldehyde content (μg) in areas of a cream declared to contain diazolidinyl urea[a]

Cream area (cm × cm)[b]	1 mg/cm^2	2 mg/cm^2
8 × 8	20	60
8 × 8	30	60
4 × 8	10	60
4 × 8	20	60
4 × 4	2.5	30
4 × 4	5	40
2 × 4	2.5	20
2 × 4	2.5	30
2 × 2	–	2.5
2 × 2	–	2.5

–, not detected.
[a]The formaldehyde content (μg) was analysed with the chromotropic acid method using standard solutions containing 2.5 μg, 5 μg, 10 μg, 30 μg, 40 μg and 60 μg of formaldehyde. The content of formaldehyde was estimated by visually comparing the intensity of the violet colour of the reagent in the samples with the colour of the reagent in the standard solutions.
[b]The cream was spread on aluminium foil (16 × 16 cm) and then cut in pieces.

Discussion

Formaldehyde and formaldehyde releasers are well-known sensitizers. Contact allergy to formaldehyde is found in around 2.5% of patients tested with the European standard series (5). Contact allergy to formaldehyde has been reported to be as common as 20.6% in a group of nurses with suspected occupational dermatitis (6). The number of gloves investigated in the present study is rather small compared to the range of glove types available according to the product catalogues provided by the producers. However, some of them are frequently brought by our patients. Obviously, the results of the study do not imply that other gloves, which were not included, do not contain formaldehyde. To the best of the knowledge of the author, the presence of formaldehyde in reusable protective gloves with flocked lining has not been reported previously.

Protective gloves can have adverse affects causing both irritant and allergic contact dermatitis (7). Both PVC gloves and NRL gloves are known to cause contact allergy (8). The additives in rubber gloves reported to cause contact allergy are accelerators, antioxidants, vulcanizers, colourants and preservatives (8). Contact allergy to cetylpyridinium chloride, a quartenary ammonium used as a disinfectant compound, has been reported to cause allergic contact dermatitis from surgical rubber gloves (9, 10). Furthermore, the preservative benzisothiazolin-3-one has been reported to cause contact allergy when added to NRL (11). The same agent has been identified as a contact allergen in glove powders in rubber gloves (12). Among plastic gloves, PVC gloves have been judged to cause most allergy problems and the plastic material itself is not considered to cause contact allergies (8). Among additives that are reported as contact allergens in PVC gloves are the plasticizer bisphenol A (13, 14). A case with contact allergy to adipic

polyester in vinyl chloride gloves has also been reported (15). Fungicides and bactericides may be added to plastic gloves (8).

The results of the present investigation suggest that formaldehyde might be added to the gloves either as such or as a formaldehyde releaser. When the gloves are analysed with the CA method, it is advised that the samples are moisturized to imitate the occlusive effect of the glove and thereby most probably give a more adequate result. The results also indicate that the inside of the gloves may contain most of the formaldehyde. Furthermore, as the index case of this study suggests, contact allergy to formaldehyde might be underestimated when tested in 1%. In a repeated open application test (ROAT) study, it was found that 39 of 58 individuals with contact allergy to formaldehyde reacted to a leave-on cream containing diazolidinyl urea (16). In the present study, when the amount of formaldehyde released from the gloves was roughly compared to a cream declared to contain a formaldehyde releaser, it was found that the gloves may emit approximately the same levels of formaldehyde as a cream declared to contain the formaldehyde releaser diazolidinyl urea. Compared to a cream, the gloves may add an occlusive effect, which may enhance penetration of contact allergens. In a follow-up study among formaldehyde-allergic patients, those who paid attention to their allergy reported having statistically significantly fewer eruptions than those who did not (17). A formaldehyde-allergic patient would have been advised to avoid products containing formaldehyde or formaldehyde releasers when choosing protective creams or other creams for the treatment of the skin. It can be suspected that the presence of formaldehyde in protective gloves might worsen or cause dermatitis in formaldehyde-allergic patients who frequently wear gloves that release formaldehyde. The time during which gloves are used should be minimized, but in some occupations, protective gloves are used for longer periods. In product catalogues, some reusable protective gloves are declared to be sanitized or treated with agents that restrain bacterial growth. The chemical agents are most often not declared. Unknowingly giving a patient the advice to use gloves that contain a chemical substance that he or she has a diagnosed contact allergy to is not desirable. On the basis of the results of the present study, it is advisable to check the patients' gloves for formaldehyde in formaldehyde-allergic patients who use reusable gloves frequently or are advised to use reusable gloves. Furthermore, to give the patients the opportunity to choose gloves based on knowledge of the content of formaldehyde or other well-known contact sensitizers would enhance the possibilities of optimized primary and secondary prevention of allergic contact dermatitis.

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