

An epidemic of furniture-related dermatitis: searching for a cause

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Summary

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Conflicts of interest

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Background Sitting in new chairs or sofas has elicited dermatitis in numerous patients in Finland and in the U.K. since autumn 2006. The cause of the dermatitis seemed to be an allergen in the furniture materials.

Objectives To determine the cause of the dermatitis in patients with furniture-related dermatitis.

Methods Altogether 42 patients with furniture-related dermatitis were studied. First, 14 Finnish patients were patch tested with the standardized series and with the chair textile material. A thin-layer chromatogram (TLC) strip and an extract made from the same textile material were tested in seven Finnish patients. The test positive spot of the TLC and the content of a sachet found inside a sofa in the U.K. were analysed by using gas chromatography–mass spectrometry. All chemicals analysed were patch tested in 37 patients.

Results A positive patch test reaction to the chair textile and to its extract was seen in all patients tested, one-third of whom had concurrent reactions to acrylates. Positive reactions to the same spot of the TLC strip were seen in five of seven patients and dimethyl fumarate was analysed from the spot as well as from the sachet contents. Dimethyl fumarate (0.01%) elicited positive reactions in all the patients. The other chemicals analysed did not elicit positive reactions, but one patient in the U.K. had a positive reaction to tributyl phosphate.

Conclusions Sensitization to dimethyl fumarate was seen in all the patients with furniture-related dermatitis. Concurrent sensitization or cross-reactions were common among the sensitized patients.

An outbreak of dermatitis elicited by imported furniture upholstery materials was recently reported in the U.K. and Finland.^{1,2} Some patients had serious oozing dermatitis covering extensive areas of the body and lower limbs as well as backs of the upper extremities. Even neck and facial dermatitis have been reported.

Before the outbreak of furniture-related dermatitis, in August 2006 a piece of fabric from a recently purchased recliner chair yielded positive patch test results in a female patient. She had purchased a Chinese 'Texas Recliner' chair

2 months before the dermatitis appeared. In addition to the positive patch test reactions to the chair textile material, multiple reactions to (meth)acrylates were also seen in the patient. Further cases of chair dermatitis and/or sofa dermatitis were reported and positive patch test reactions to (meth)acrylates were seen in these patients more often compared with populations with common contact dermatitis. During the first half of 2008 the cause of the dermatitis was independently revealed by three groups^{1–4} and new cases were reported from other countries.⁵ In this article we

describe the stepwise procedures including patch testing with extracts and thin-layer chromatograms (TLCs) as well as the gas chromatography–mass spectrometry (GC-MS) investigations used by our group.

Materials and methods

Patch test occasion I

Patients

Fourteen patients with suspected chair dermatitis were studied. The age of the patients ranged between 34 and 67 years (seven women and seven men). The dermatitis had appeared 2 weeks to 5 months after the purchase of the chair. The first patient was studied in August 2006 (patient 1 in Tables 2–4). Her swollen, erythematous and oozing dermatitis patches on the buttocks and backs of the thighs healed after several recurrences when she discontinued sitting in her new chair following the skin tests with the chair textile material which had shown positive reactions. Three patients were hospitalized due to an extensive oozing/scaling dermatitis and one of them (patient 6 in Table 2) is seen in Figure 1.



Fig 1. A male patient with a typical 'chair dermatitis' (patient 6 in Table 2).

Patch tests

The patients were patch tested with the European baseline series (Chemotechnique, Vellinge, Sweden), together with a modified series of glues and plastics comprising selected (meth)acrylates. The patch test chemicals were applied to the upper part of the back in Finn Chambers (Epitest Ltd, Tuusula, Finland) on Scanpor tape (Norgesplaster A/S, Venne, Norway). The test chambers were removed 2 days after the application, and were read and interpreted 1–3 days after the removal (days 3, 4 or 5) according to the International Contact Dermatitis Research Group criteria.

Patch testing was carried out with the textile from the patient's own chair and/or with the similar chair textile from the chair of patient 2 (in Table 2), moistened with saline and/or with acetone. Twenty control subjects (six employees of the dermatology clinic and their family members and 14 patients with dermatitis) were tested with the chair textile (of patient 2) correspondingly.

Preparation of the chair extract

Textile material from a chair that was the suspected cause of dermatitis in a Finnish patient was extracted. The extract was made from 3.6 g of the textile that was treated with about 50 mL acetone in an ultrasonic bath for 5 min. The volume of the acetone phase was then reduced to 2.0 mL in an evaporator and the resulting extract was used for patch testing and analysis. This extract is from now on referred to as 'the chair extract'.

Preparation of thin-layer chromatograms for patch testing

TLCs for patch testing⁶ were prepared by applying the chair extract on to a sheet of thin-layer material with silica gel bound to a plastic carrier (Silica Gel 60 F₂₅₄ plastic roll 500 × 20 cm; Merck KGaA, Darmstadt, Germany). Strips, 18 × 18 cm, were cut out and 15 µL of the extract was applied from a capillary pipette on one spot every 2.5 cm along a straight line on the lower part of the plate constituting the starting points of a series of six chromatograms. Elution was done with a mobile phase consisting of chloroform and acetonitrile (86/14 v/v). When the solvent had evaporated from the developed TLC sheets, they were cut into strips, approximately 15 × 150 mm, which were used for patch testing.

Patch test occasion II

Three to ten months after patch test occasion I, the chair extract (as described above), acetone dilutions of the extract of 10% and 1.0% w/v, and the TLC strips prepared from the chair extract were used for patch testing in seven of the 14 Finnish patients also tested on patch test occasion I.

Sample preparation for analysis of positive thin-layer chromatogram spot

The positive spot on a TLC strip similar to the one that the patient had been patch tested with was scraped out and the silica gel powder was put in a small, 3 mL, jar with a Teflon cap. Two hundred and fifty microlitres of ethyl acetate was added, the jar was shaken for 1 min, the solvent was filtered and the resulting solution was used for analysis.

Gas chromatography–mass spectrometry

Separation of components in the samples was performed with an Agilent 6890N gas chromatograph (Agilent Technologies, Palo Alto, CA, U.S.A.) equipped with an HP-MSI capillary column (Agilent Technologies) with a length of 30 m, an internal diameter of 0.25 mm and a film thickness of 0.25 µm. Helium of Alphagaz™ 2 quality (Air Liquide, Malmö, Sweden) was the carrier gas with a flow rate of 1.0 mL min⁻¹. The injection was splitless and the inlet was heated to 250 °C. The injection volume was 1 µL. The temperature program was isothermal at 70 °C for 3 min, then raised by 8 °C min⁻¹ to a final temperature of 300 °C and was isothermal at this temperature for 10 min.

Electron-ionization mass spectra were recorded from components in the analysed samples with a Jeol GCmate II mass spectrometer (Jeol Datum Ltd, Tokyo, Japan), in scan mode, recording ions with *m/z* from 50 to 600 u, with a scan duration of 0.3 s and an interscan delay of 0.2 s. The temperature of the ion source was 250 °C and the GC-MS interface temperature was 250 °C. The electron energy was 70 eV. The National Institute of Standards and Technology library of mass spectra was used for identification.

Analysis of the mould-proof agent

Our group received a request from the BBC in the U.K. to analyse the contents of a small nonwoven sachet which had

been found under the covering textile of a sofa of the same brand as those suspected of having caused dermatitis in a large number of U.K. patients. The sachet was marked 'mouldproof agent, do not eat'. The sachet is shown in Figure 2. From the powder inside the sachet a 0.01% w/v solution was made in ethyl acetate. After filtration the solution was analysed with GC-MS.

Chemicals

The following chemicals were used in this investigation: acetone in analytical grade and chloroform in reagent grade (Scharlau Chemie S.A., Sentimenal, Spain); ethyl acetate, methanol in high-performance liquid chromatography (HPLC) gradient grade and acetonitrile in ultragradient HPLC quality (Malinkrodt Baker BV, Deventer, the Netherlands); dimethyl fumarate 97%, tributyl phosphate 99+%, 2,6-dichloro-4-nitroaniline (Dichloran) 96% and nonanal 95% (Sigma Aldrich, St Louis, MO, U.S.A.); tris-(2-chloroethyl) phosphate (Acros Organics, Geel, Belgium); 2-bromo-4,6-dinitroaniline 97% and decanal 96% (Alfa Aesar GmbH & Co. KG, Karlsruhe, Germany); tris-(2-chloropropyl) phosphate and tris-(2-chloroisopropyl) phosphate (Pfaltz & Bauer, Inc., Waterbury, CT, U.S.A.).

Patients and patch test occasion III

Patch test series for patients with suspected or confirmed furniture dermatitis

Patch test preparations from the substances found in the GC-MS analysis of the positive spot on the TLC strip were prepared in the Malmö laboratory. Based on the results of the analysis a patch test series for the patients with furniture-related dermatitis was developed (Table 1). It was tested in nine Finnish (patients 1–7 and 36 and 37 in Table 4) and 28 British patients (patients 8–35 in Table 4) with confirmed or suspected furniture-related dermatitis.

Results

Patch test occasion I

Patch test reactions to the chair textile and to standard test substances

Skin test reactions to the chair textile and to substances in the baseline series and to those in the series of glues and plastics at the time of first skin testing are shown in Table 2. Patch test reactions to substances in the baseline series were seen in five patients.

Each patient had positive patch test reactions to the chair textile, moistened with saline and/or with acetone. Reactions to (meth)acrylates were seen in five of the 14 patients, all of whom reacted to ethyl acrylate, and four to 2-hydroxyethyl methacrylate.



Fig 2. The sachet with the mould-proof agent found by investigators from the BBC in a sofa suspected of having caused dermatitis in the U.K.

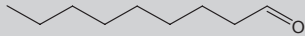
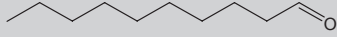
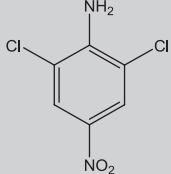
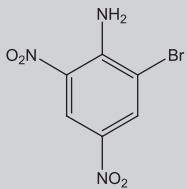
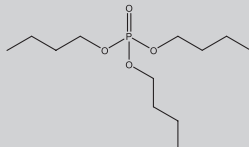
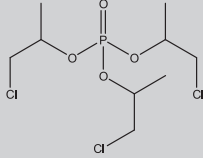
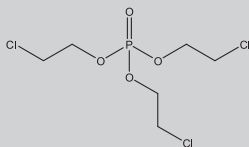
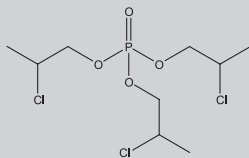
Substance	CAS	MW	Concentration (% w/w in pet.)
Nonanal	124-19-6	142	1.0 0.1
			
Decanal	112-31-2	156	1.0 0.1
			
2,6-Dichloro-4-nitroaniline	99-30-9	207	0.1 0.01
			
2-Bromo-4,6-dinitroaniline	1817-73-8	262	0.1 0.01
			
Tributyl phosphate	126-73-8	266	1.0 0.1
			
tris-(2-Chloroisopropyl) phosphate	13674-84-5	327	1.0 0.1
			
tris-(2-Chloroethyl) phosphate	115-96-8	285	1.0 0.1
			
tris-(2-Chloropropyl) phosphate	6145-73-9	327	1.0 0.1
			

Table 1 The substances identified in the positive thin-layer chromatography spot with their chemical structure, Chemical Abstracts Services number (CAS), molecular weight (MW) and their concentrations in the developed patch test series

Table 1 (Continued)

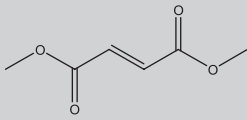
Substance	CAS	MW	Concentration (% w/w in pet.)
Dimethyl fumarate	624-49-7	144	0.1 0.01 0.001 0.0001 0.00001
			
pet., petrolatum.			

Table 2 Patch test occasion I. Results from patch testing with the baseline series and additional test series. Only substances testing positively in one or more patients are included

	Patient													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Test material														
Textile as is	++	++	++	++	+	+	++	+	++	+	++	+	++	++
Baseline series														
Perfume mix I	+	–	nt	–	+	–	–	–	–	–	–	–	–	–
Perfume mix 2	+	–	nt	–	–	–	–	–	–	–	–	–	–	–
Nickel sulphate	–	–	nt	–	–	–	–	–	–	–	+	–	–	–
p-Phenylenediamine	–	–	nt	–	–	–	–	–	–	–	–	+	–	–
Paraben mix	–	–	nt	–	–	–	–	–	–	–	–	–	+	–
Additional series														
2-Hydroxyethyl methacrylate	+	–	nt	–	–	++	++	–	+	–	–	–	–	–
Ethyleneglycol dimethacrylate	+	–	nt	–	–	+	–	–	–	–	–	–	–	–
2-Hydroxypropyl methacrylate	nt	nt	nt	nt	–	+	++	–	–	–	–	–	–	–
Methyl methacrylate	+	–	nt	–	–	++	–	–	–	–	–	–	–	–
Ethyl acrylate	++	–	nt	–	–	+	+	–	+	–	–	–	–	+

nt, not tested.

Table 3 Patch test occasion II. Results from patch testing of the chair extract and the thin-layer chromatogram test strip made from the chair extract

	Patient ^a						
	1	2	3	4	11	12	13
Chair extract							
As is	++	+	++	++	+	+	++
10%	+?	–	–	–	–	–	–
1%	–	–	–	–	–	–	–
Reaction to thin-layer chromatogram test strip ^b	++	+	+	++	–	–	+

^aPatient numbers correspond to those in Table 2. ^bAll positive reactions occurred to the same 'invisible spot' indicated in Figure 3. +?, doubtful reaction.

Patch test occasion II

Skin test reactions to thin-layer chromatography strips and to acetone extracts of the textile

Positive patch test reactions to the acetone extract of the chair textile were seen in each of the seven patients tested. TLC tests were positive in five of the seven patients (Table 3). In each

case the reaction was seen to the same area of the TLC strip (Fig. 3).

Analysis of thin-layer chromatography strips and the mould-proof agent

GC-MS analysis of the positive TLC spot showed the presence of nine identifiable substances, one of which was dimethyl

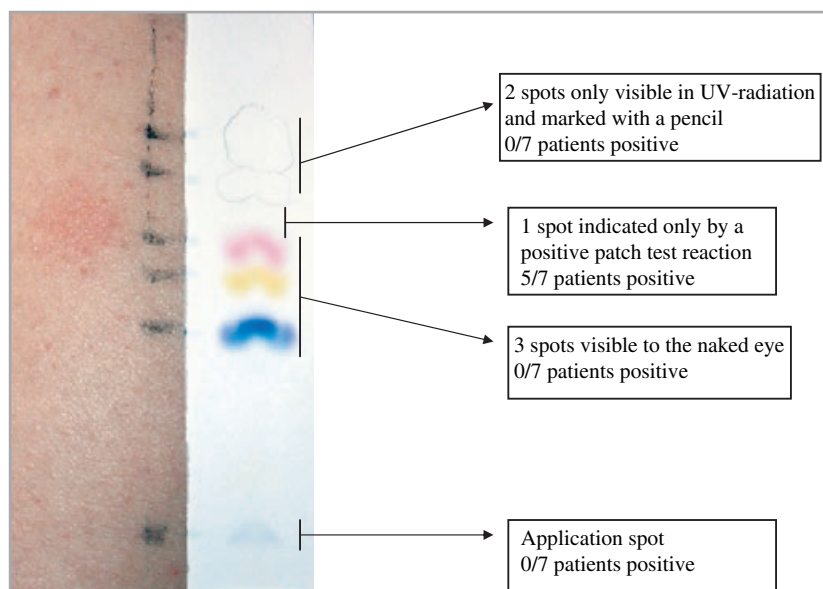


Fig 3. Positive patch test reaction to a thin-layer chromatogram test strip made from the chair extract.

fumarate (Table 1). GC-MS analysis of the powder from the nonwoven sachet showed that it consisted of dimethyl fumarate (Fig. 2).

Patch test occasion III

Patch test reactions to the chemicals analysed in the positive thin-layer chromatography spot

One from the nine chemicals analysed in the skin test positive spot of the TLC strip was the relatively volatile dimethyl fumarate. Patch testing with dimethyl fumarate 0.01% in petrolatum (pet.) yielded positive patch test reactions in all patients tested (Table 4) and two patients had positive reactions to 0.0001% dimethyl fumarate. One patient without any reaction to the TLC strip had a positive reaction to 0.01% dimethyl fumarate (patient 12 in Tables 2 and 3 and patient 5 in Table 4).

Patch tests with the other chemicals analysed in the TLC spot were negative in the TLC-tested patients, as seen in Table 4. Tributyl phosphate (1.0% pet.), tris-(2-chloroisopropyl) phosphate and tris-(2-chloroethyl) phosphate were negative in the seven TLC-tested patients. The rest of the chemicals analysed in the TLC spot were tris-(2-chloropropyl) phosphate (1.0% pet.), 2,6-dichloro-4-nitroaniline (0.10% pet.), 2-bromo-4,6-nitroaniline (0.10% pet.), nonanal (1.0% pet.) and decanal (1.0% pet.) and they were negative in both tested patients.

The patch test with dimethyl fumarate was positive and the rest of the patch tests with the chemicals analysed in the TLC spot were negative in 36 patients with furniture-related dermatitis, 17 of whom were tested with all nine chemicals and 19 with tributyl phosphate (1.0% pet.), tris-(2-chloroisopropyl) phosphate and with tris-(2-chloroethyl) phosphate. One patient (patient 23 in Table 4) with a positive patch test

reaction to 0.001% dimethyl fumarate had a positive patch test reaction to tributyl phosphate (1.0% pet.).

Discussion

It became apparent early on that the patients had developed contact sensitization to chair materials, as none of the control subjects showed reactivity to the chair textiles. An additive to the upholstery material rather than a specific textile chemical was suspected, as other patients in Finland and later on in the U.K. with furniture-related dermatitis developed dermatitis from differently designed upholstery materials including textiles and leather. Initially, acrylates were suspected as many patients tested positive to these (Table 2). However, chemical investigations with GC-MS did not reveal any acrylates in the upholstery material. When asked, the manufacturer of the chairs denied the addition of any chemical. Thus, chemical investigations to find the sensitizer were needed. With the old technique, the isolation and identification of a primarily totally unknown contact sensitizer in a product is usually a laborious, time-consuming and costly procedure. The development of the TLC patch testing technique with a combined biological and chemical approach has significantly facilitated the identification of a contact sensitizer in a product.⁶ Positive reactions to the same spot on the TLC strip revealed that the allergen was present in that spot. The amount of dimethyl fumarate detected in the chromatogram was minor. When making the TLC in Sweden for patch testing in Finland it was not known that the sensitizer was highly volatile and thus a considerable amount of dimethyl fumarate had probably already evaporated from both the extracted textile and the TLC materials during transport and storage. The concentration of dimethyl fumarate in the TLC strips was most probably below 0.01% as two patients tested negatively to the strip.

Table 4 Patch test occasion III. Results from patch testing with patch test series for patients with suspected/confirmed furniture-related dermatitis. Patients 1–7 and patients 36 and 37 were tested in Finland, the other patients were tested in the U.K.

Substance	Concen- tration (%) w(w pet.)																																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37		
Nonanal	1·0	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	nt	nt	
Decanal	0·1	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	nt	nt	
	1·0	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	nt	nt	
2,6-Dichloro-4-nitroaniline	0·1	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	nt	nt	
	0·01	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	nt	nt	
2-Bromo-4,6-dinitroaniline	0·1	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	0·01	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Tributyl phosphate	1·0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
tris-(2-Chloroisopropyl) phosphate	0·1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	1·0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
tris-(2-Chloroethyl) phosphate	1·0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	0·1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
tris-(2-Chloropropyl) phosphate	1·0	–	–	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	0·1	–	nt	nt	nt	nt	nt	–	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Dimethyl fumarate	0·1	nt	nt	nt	+++	nt	+++	nt	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
	0·01	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		
0·001	++	+	++	–	–	–	+	+	–	+	–	–	+	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
0·0001	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
0·00001	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	

pet., petrolatum; nt, not tested; +?, doubtful reaction.

It was shown in the U.K. that small sachets were present inside sofas imported from China and dimethyl fumarate was found to be the main content of the sachets. An antifungal effect was expected from the volatile dimethyl fumarate inside the upholstery materials of the furniture. The chairs and sofas had been wrapped and loaded for transportation. When the plastic packaging was unwrapped in homes the amount of dimethyl fumarate was still sufficient to sensitize and to elicit contact dermatitis. Some of the sensitized patients had positive reactions to very low concentrations of dimethyl fumarate. Some patients described symptoms of airborne allergen exposure. The chair had to be taken away from the house to allow the patient to recover from pruritus and recurrent dermatitis. The concentration of the volatile dimethyl fumarate in new chairs was probably high and, additionally, spot-like variation in concentrations must have occurred. Some of these patients had swollen, erythematous patches on the buttocks and backs of the thighs corresponding to spot-like occurrence of the allergen.

A mixture of fumaric acid esters (Fumaderm®) has been used as an antipsoriatic drug⁷ and fumaric acid esters have also shown efficacy in the treatment of necrobiosis lipoidica.⁸ An oral formulation of dimethyl fumarate was shown to reduce new inflammatory lesions in patients with relapsing–remitting multiple sclerosis.^{9,10} In oral systemic medication abdominal pain, flushing and hot flushes have been described as the most common side-effects.^{7–10} Increased vasodilatation in the skin might be expected in topical exposure. In more than 20 control subjects tested with 0.01% dimethyl fumarate in petrolatum we have not seen erythematous or other irritant reactions. However, the concentration of dimethyl fumarate in recently purchased chairs and sofas must have been higher. Thus, an increased vasodilatation in contact areas probably increased cutaneous penetration.

Dimethyl fumarate has been reported to modulate T-cell responses^{9,11} and inhibition by fumaric acid esters of dendritic cell differentiation has been described.¹² Skin penetration of the allergen was assisted by the body weight and some sweating. Before test occasion I in our study two patients had suffered from serious extensive dermatitis and both of them weighed more than 100 kg (200 lbs). The degree of sensitization was high among the sensitized patients, as 16 out of 37 patients still reacted to 0.001% and three to a 0.0001% concentration of dimethyl fumarate. High induction dose per unit area has been regarded as important in the elicitation of contact sensitization.¹³ The first patient (patient 1 in Tables 2–4) was an apparent example of this.

Although dimethyl fumarate was the apparent sensitizer in the furniture materials, one patient also had a positive reaction to tributyl phosphate (1.0% pet.). Tributyl phosphate has been used as a solvent and plasticizer in cellulose esters and as a solvent in inks, adhesives, resins, herbicides and fungicides. It is also used as a defoaming agent in solutions and emulsions and it also has a bactericidal effect against certain bacteria. Skin irritation or cutaneous sensitization has not been documented in recent toxicity studies.^{14,15}

Patch test reactions to ethyl acrylate, 2-hydroxyethyl methacrylate, triethylene glycol dimethacrylate and to methyl methacrylate were seen in the first patient, who seemed to have no history of corresponding exposure. As none of these substances was detected in the textile extract when investigated with GC-MS (unpublished data), cross-reactivity appeared the most evident explanation. Although sensitization to (meth)acrylates most commonly comes from occupational exposure in dentistry,^{16–18} from artificial nails¹⁹ and from glues or adhesives,²⁰ sources of primary sensitization may remain unresolved in some patients.

Sensitization to dimethyl fumarate was apparent in all these patients with furniture dermatitis. Our results confirm dimethyl fumarate as the cause of the epidemic of a furniture-related dermatitis. The allergen was detected in furniture upholstery textiles. Primary sensitization to dimethyl fumarate from different sources cannot be excluded. Secondary cross-reactivity to multiple different chemicals is an interesting topic and sources of cross-reacting chemicals may sometimes represent sources of primary sensitization. The appearance of cross-reactions and the possibility of primary sensitization from different sources need further investigation.

References

- Williams JD, Coulson IH, Susitaival P, Winhoven SM. An outbreak of furniture dermatitis in the U.K. *Br J Dermatol* 2008; **159**:233–4.
- Rantanen T. The cause of the Chinese sofa/chair dermatitis epidemic is likely to be contact allergy to dimethylfumarate, a novel potent contact sensitizer. *Br J Dermatol* 2008; **159**:218–21.
- Foulds I. An investigation of the cause of sofa dermatitis, results and the discovery of a new sensitizer. *Contact Dermatitis* 2008; **58** (Suppl. 1):40.
- Zimerson E, Gruvberger B, Susitaival P *et al.* An epidemic of furniture related dermatitis – chemical investigations. *Contact Dermatitis* 2008; **58** (Suppl. 1):39.
- Imbert E, Chamailard M, Kostrzewa E *et al.* Chinese chair dermatitis: a new form of contact dermatitis [in French]. *Ann Dermatol Venerol* 2008; **135**:777–9.
- Bruze M, Frick M, Persson L. Patch testing with thin-layer chromatograms. *Contact Dermatitis* 2003; **48**:278–9.
- Harries MJ, Chalmers RJ, Griffiths CE. Fumaric acid esters for severe psoriasis: a retrospective review of 58 cases. *Br J Dermatol* 2005; **153**:549–51.
- Kreuter A, Knierim C, Stücker M *et al.* Fumaric acid esters in necrobiosis lipoidica: results of a prospective noncontrolled study. *Br J Dermatol* 2005; **153**:802–7.
- Sorensen PS, Sellebjerg F. Oral fumarate for relapsing–remitting multiple sclerosis. *Lancet* 2008; **372**:1447–8.
- Kappos L, Gold R, Miller DH *et al.* BG-12 Phase IIb Study Investigators. Efficacy and safety of oral fumarate in relapsing–remitting multiple sclerosis: a multicentre, randomised, double-blind, placebo-controlled phase IIb study. *Lancet* 2008; **372**:1463–72.
- Moed H, Stoof TJ, Boorsma DM *et al.* Selective stimulation of T helper 2 cytokine responses by the anti-psoriasis agent monomethylfumarate. *Clin Exp Allergy* 2004; **34**:1868–75.
- Zhu K, Mrowietz U. Inhibition of dendritic cell differentiation by fumaric acid esters. *J Invest Dermatol* 2001; **116**:203–8.

- 13 Basketter DA, Clapp C, Jefferies D *et al.* Predictive identification of human skin sensitization thresholds. *Contact Dermatitis* 2005; **53**:260–7.
- 14 Hamouda T, Myc A, Donovan B *et al.* A novel nanoemulsion with a unique non-irritant topical antimicrobial activity against bacteria, enveloped viruses and fungi. *Microbiol Res* 2001; **156**:1–7.
- 15 Michel K, Brinkmann C, Hahn S *et al.* Toxicity investigations of ester-based lubricants by using biotest with algae and bacteria. *Environ Toxicol* 2004; **19**:445–8.
- 16 Geukens S, Goossens A. Occupational contact allergy to (meth)acrylates. *Contact Dermatitis* 2001; **44**:153–9.
- 17 Aalto-Korte K, Alanko K, Kuuliala O, Jolanki R. Methacrylate and acrylate allergy in dental personnel. *Contact Dermatitis* 2007; **57**:324–30.
- 18 Goon AT, Isaksson M, Zimerson E *et al.* Contact allergy to (meth)acrylates in the dental series in southern Sweden: simultaneous positive patch test reaction patterns and possible screening allergens. *Contact Dermatitis* 2006; **55**:219–26.
- 19 Constandt L, Hecke EV, Naeyaert JM, Goossens A. Screening for contact allergy to artificial nails. *Contact Dermatitis* 2005; **52**:73–7.
- 20 Aalto-Korte K, Alanko K, Kuuliala O, Jolanki R. Occupational methacrylate and acrylate allergy from glues. *Contact Dermatitis* 2008; **58**:340–6.