

Occupational dermatoses among fibreglass-reinforced plastics factory workers

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Fibreglass-reinforced plastics (FRP) factory workers are at high risk of developing occupational dermatoses because of their exposure to many chemicals used in the manufacture of plastics as well as to glass fibre or dust. Patch tests were carried out on 29 workers involved in FRP manufacturing processes where unsaturated polyester (UP) resin was used, to investigate the causes of their skin problems. Of the 22 workers who reported experiencing skin problems, 16 showed positive results to at least 1 chemical, including 6 cases of multiple sensitivity. 2 showed positive reactions to UP base resin, 6 to cobalt chloride, 5 to benzoyl peroxide (BPO), 4 to methyl ethyl ketone peroxide (MEKPO), 2 to *para*-tertiary butyl catechol (PTBC), 1 to styrene and 1 to formaldehyde. After taking into account their exposures and reported causes by questionnaires and their patch test results, 7 cases were diagnosed as allergic contact dermatitis (ACD) due to chemicals, 3 as irritant contact dermatitis (ICD) due to chemicals, and 3 as dermatitis due to mechanical irritation (MI) from glass fibre or dust, as well as 9 as ACD and/or MI. 18 of the total of 29 subjects (62.1%), including 2 workers without a history of skin problems, were sensitized to at least 1 chemical. Cobalt, peroxides, PTBC and UP base resin were the common causes of ACD.

Key words: allergic contact dermatitis; benzoyl peroxide; cobalt; fibreglass-reinforced plastics; irritant contact dermatitis; mechanical irritation; methyl ethyl ketone peroxide; occupational; *para*-tertiary butyl catechol; unsaturated polyester resin. © Blackwell Munksgaard, 2002.

Accepted for publication 6 March 2002

Fibreglass-reinforced plastics (FRP) have been widely used in marine and domestic applications over the last 5 decades. FRP workers are at risk of developing dermatitis due to mechanical irritation (MI) from glass fibre used as reinforcers and dust produced by cutting or grinding cured FRP, and both irritant contact dermatitis (ICD) and allergic contact dermatitis (ACD) caused by chemicals used as the matrix of the FRP products (1, 2).

Unsaturated polyester (UP) resin, consisting of base resin, styrene and auxiliary chemicals, is used most often as the matrix of FRP products. Allergy to UP resin and hardening catalysts has been reported since the 1960s, but not very frequently (1–21). UP base resin is produced by esterification of di- or polybasic organic acid or anhydride and di- or polyhydric alcohol. Styrene is used as a cross-linking agent. The base resin components such as maleic anhydride (MAN) or its intermediate substance in the process of the esterification can cause allergy, although such reports are rare (3–8). Auxiliary ingredients, such as cobalt naphthenate (8–11) or dimethylaniline used as an accelerator,

para-tertiary butyl catechol (PTBC) (12, 13) or hydroquinone used as an inhibitor, and styrene (14) are more often reported as allergens than UP base resin. Hardener, whose main ingredients are methyl ethyl ketone peroxide (MEKPO) (15–17) or benzoyl peroxide (BPO) (18–21), is added to UP resin as a catalyst and often causes ICD or ACD (8). Furthermore, immediate-type allergy due to latex in natural rubber latex (NRL) gloves has been reported as causing dermatitis in FRP workers (1).

We have previously reported on the skin problems of 148 FRP workers (22). Patch tests were performed on 29 of these 148 workers. The first aim of this study was to investigate which chemicals of UP systems used in the FRP manufacturing process sensitized them. Secondly, by analysing the relationship between their patch test results and their history of exposures to hazardous substances of FRP manufacturing and reported symptoms, a diagnosis of ACD, ICD or MI would be made so as to clarify the causes of occupational dermatoses among these FRP workers.

Materials and Methods

Subjects

2 field surveys, 1 in the winter and the other in the summer (1997–8), were conducted in 11 small-to-medium-sized FRP factories in Kumamoto Prefecture in the southern part of Japan (22). These 11 factories, among 15 small-to-medium-sized factories that were identified in Kumamoto Prefecture, were visited after permission had been obtained from each factory's administrator. 148 workers involved in the manufacturing process completed a questionnaire that asked about their FRP work record, the kinds of work-related skin problems experienced, glove usage and history of allergic diseases. A dermatological examination was also carried out on exposed areas of the body.

3 months later, workers in 5 of the 11 factories were asked to take part in patch testing, after being provided with an oral explanation of the purpose and procedures of the study. The other 6 factories were not available because of poor economic status or the administrators' unwillingness to co-operate in this survey. All the workers in 3 of the 5 factories declined to participate. In the other 2 factories, 23 of the 26 workers in factory A and all 6 workers in factory B agreed to participate and signed consent forms.

Patch test survey

4 kinds of UP resin (a, a', b, and b') used in factory A and two kinds of UP resin (c and d) in factory B were prepared for patch testing at 5% (w/w) in petrolatum (pet.). The outer gloves used by the workers, provided for the patch test survey by both factories, were made of NRL. Dust was collected from sawing or grinding sites at the 2 factories as one of the tested substances. In addition, high ammoniated latex sheet (Tore Co., Tokyo, Japan) and rubber chemicals (Trolab, Hermal, Germany) were tested. Putative allergens from plastics and glues series (Trolab and Chemotechnique Diagnostics AB, Malmö, Sweden) were used (2, 5). Some possible allergens, which were not commercially available (Table 4), were prepared in the laboratory at concentrations recommended by Fisher (2). The Finn Chamber technique (23) with occlusion time of 2 days was used for the patch tests, which were read 1 day after removal of the chambers following International Contact Dermatitis Research Group (ICDRG) criteria (24).

Patch test with UP base resin and its components

A 2nd patch test session was undertaken on 2 subjects who were found positive to UP resins (a and

Table 1. Comparison of work-related exposure factors between patch test survey participants and non-participants (n = 148)

	Patch test survey participants	Patch test survey non-participants	Field survey	p-value
Total number of subjects (Male, Female)	29 (M27, F2)	119 (M103, F16)	148 (M130, F18)	N.S.
Mean age in years (S.D)	45.8 (10.1)	43.0 (14.4)	43.5 (13.8)	N.S.
Mean years of exposure (S.D)	15.9 (9.6)	8.7 (8.8)	10.0 (9.3)	< 0.001
Number of subjects with history of work-related skin symptoms	22 (75.8%)	65 (54.6%)	87 (58.8%)	< 0.05
Number of subjects with history of allergic diseases	7 (24.1%)	29 (24.4%)	36 (24.3%)	N.S.
Working stage involved				
lamination process only	5 (17.2%)	38 (31.9%)	43 (29.1%)	< 0.05
postlamination process only*	0 (0%)	27 (22.7%)	27 (18.2%)	
both processes	24 (82.8%)	54 (45.4%)	78 (52.7%)	
Current glove usage				
always	18 (62.1%)	72 (60.5%)	90 (60.8%)	N.S.
almost always	6 (20.7%)	32 (26.9%)	38 (25.7%)	
sometimes	4 (14.8%)	14 (11.8%)	19 (12.8%)	
occasionally or never	1 (3.4%)	0 (0%)	1 (0.7%)	
Glove materials**				
natural rubber	27 (93.1%)	91 (76.5%)	118 (79.7%)	< 0.05
polyvinyl chloride	0 (0%)	13 (10.9%)	13 (8.8%)	N.S.
gunte***	7 (24.1%)	68 (57.1%)	75 (50.7%)	< 0.05
cotton (as inner gloves)	2 (6.9%)	12 (10.1%)	14 (9.5%)	N.S.
leather	6 (20.7%)	8 (6.7%)	14 (9.5%)	< 0.05

*Sawing, grinding and assembling of cured FRP.

**Multiple answers were permitted.

***Mixture of synthetic fabric and cotton, used for carpentry and other purposes as outer gloves.

a'). The 2 kinds of UP resins (a and a') had the same base resin (a condensation product of MAn, phthalic anhydride (PAn), ethylene glycol and dicyclopentadiene (DCPD)) but their auxiliary chemicals were slightly different (information supplied by the manufacturer). The UP base resin and the 4 major components of the base resin were tested. The base resin and DCPD were provided by the manufacturer and prepared at 5% and 1% (w/w) and 2%, 1% and 0.5% (w/w), respectively, in pet. MAn and PAn were obtained from Nacalai tesque (Tokyo, Japan) and prepared at 1% (w/w) in 70% alcohol and in distilled water, respectively.

Diagnosis

A diagnosis of ACD was made if a worker described the lamination process as the cause of his/her skin problem and showed a positive reaction to any of the patch test chemicals, while a diagnosis of ICD was made if a worker described the lamination process as the cause of his or her skin problem and showed no reactions on patch testing. A diagnosis of dermatitis due to MI was made if a worker was completely negative on patch testing and claimed glass fibre or dust as a cause. If a worker showed a positive reaction to any of the chemicals but claimed glass fibre or dust in the postlamination process as a cause, a specific diagnosis could not be made; these cases were diagnosed as 'ACD and/or MI'.

Results

Subject characteristics and history of work-related skin symptoms

87 of the 148 workers (58.8%) reported having some form of skin symptoms (mainly itching or eczema), mostly on the hand, since they began working in the FRP factory. Work-related exposure factors of the 148 workers and their glove usage at the time of the field survey are summarized in Table 1. Localization of skin symptoms and the causes reported by the 87 workers are summarized in Table 2. Almost 50% (40/87) of the workers with a history of skin problems reported exacerbation of symptoms in the summer time. 13 of the 87 workers said that they were not wearing any kind of gloves at the time they first experienced skin symptoms. 128 of the 148 workers (86.5%) reported that they were currently using gloves either at all times or almost always. All employees were provided with outer gloves, most of which were made of NRL.

Patch test survey

Factory A (23 workers; 22 male and 1 female) used hand lay-up and spray-up as lamination methods to produce pools, boats and bathtubs. Factory B (6 workers; 5 male and 1 female) used only hand lay-up and produced water tanks and ducts. Both factories used UP resin as matrices of FRP products and glass fibre mat with a diameter of 10 μ m

Table 2. Recurrence, localization and reported causes of work-related skin problems ($n = 87$)

	Patch test survey participants ($n = 22$)	Patch test survey non-participants ($n = 65$)	Subjects with history of skin problems of filed survey ($n = 87$)
Recurrence			
yes (summer exacerbation)	13 (10)	42 (30)	55 (40)
no	9	23	32
Localization			
hands	21	60	81
foot	5	18	23
upper extremities	5	13	18
lower extremities	2	6	8
neck	2	4	6
face	0	3	3
Causes reported by workers*			
dust	8	27	35
glass fibre	10	22	32
resin	5	16	21
rubber gloves	7	14	21
acetone	0	11	11
hardener	0	9	9
glue	0	1	1
don't know	2	7	9

*Multiple answers were permitted.

Table 3. Characteristic of subjects, skin problems, patch test results and possible diagnosis

Case no.	Fac-tory	Sex	Age	Allergic disease history	Period of exp.*	Period to onset****	Ex-posure*** lam.	Post lam.	Working stage skin problems reported by subjects	Causes reported by subjects	Skin symptom	Localization of symp.					Eczema observed		Patch test results	Diagnosis	
												hands	foot	u.extr.	l.extr.	neck	winter	summer			
1	A	M	58	–	30.8	0.2	+	+	lamination	resin, gloves	recurrent eczema	+	–	–	–	–	–	+	(hands)	UP resin + (a and a') cobalt chloride+	ACD
2	A	M	57	–	24.1	19.5	+	–	lamination	do not know	recurrent eczema	+	–	–	–	–	–	+	(hands)	UP resin +eczema cobalt chloride+	ACD
3	A	M	35	–	17	17	+	+	lamination	gloves	recurrent	+	–	–	–	–	–	N.E.		cobalt chloride+	ACD
4	A	M	24	–	9.3	5	+	–	lamination	resin	temporal	+	–	–	–	–	–	–		cobalt chloride+	ACD
5	A	M	50	–	11.7	5.1	+	+	lamination	gloves	temporal eczema	+	–	–	–	–	–	–		cobalt chloride+	ACD
6	A	M	58	–	27	10	+	+	lamination	resin, gloves	recurrent eczema	+	–	–	–	+	–	–		cobalt chloride+	ACD/MI
7	A	M	51	urticaria	26.7	0	+	+	lamination cutting and grinding	glass fibre dust	temporal eczema	+	+	–	+	–	–	–		BPO+	ACD/MI
8	A	M	34	–	18.3	0	+	+	grinding	glass fibre dust	recurrent eczema	+	–	+	–	–	N.E.	–		BPO+	ACD/MI
9	A	F	46	–	5.4	0.3	+	+	glass fibre mat cutting	glass fibre	continuous itching		+	–	–	–	–	–	–		BPO?+ ACD/MI
10	A	M	53	–	24.1	19	+	–	lamination	resin, gloves	recurrent eczema	+	–	–	–	–	–	–		MEKPO+	ACD
11	A	M	43	urticaria	11.71	1.2	+	+	lamination cutting and grinding	glass fibre	temporal eczema	+	–	+	–	–	–	–		formalde- hyde	ACD/MI
12	A	M	39	urticaria	5.9	5.7	+	+	grinding	dust	temporal eczema	+	+	–	–	–	–	–		MEKPO+ MEKPO?+	ACD/MI
13	A	M	27	–	1.2	0.8	+	+	grinding	dust	recurrent eczema	+	–	+	–	–	–	N.E.		PTBC+	ACD/MI
13	A	M	27	–	1.2	0.8	+	+	grinding	dust	recurrent eczema	+	–	+	–	–	–	N.E.		PTBC+	ACD/MI
14	A	M	34	–	9.7	2	+	+	lamination	gloves	recurrent eczema	+	+	–	–	–	+(hands)	–		all negative	ICD
15	A	M	48	–	22.1	12.4	+	+	lamination	gloves	recurrent eczema	+	–	–	–	–				all negative	ICD
16	A	M	33	–	15.8	13.2	+	+	lamination	resin, acetone	temporal eczema	+	–	–	–	–	–	–		all negative	ICD

Table 3. Characteristic of subjects, skin problems, patch test results and possible diagnosis

Case no.	Fac-tory	Sex	Age	Allergic disease history	Period of exp.*	Period to onset***	Ex-posure*** lam.	Post lam.	Working stage skin problems reported by subjects	Causes reported by subjects	Skin symptom	Localization of symp.					Eczema observed		Patch test results	Diagnosis
												hands	foot	u.extr.	l.extr.	neck	winter	summer		
17		A	M	urticaria rhinitis	12.7	0.2	+	+	grinding	dust	tempora eczema	+	-	-	-	-	-	-	all negative	MI
18	A	M	54	-	11.8	0.3	+	+	grinding	glass fibre, dust	temporal eczema	+	+	+	+	+	-	-	all negative	MI
19	B	M	31		11.1	10.2	+	+	grinding	glass fibre, dust	recurrent eczema	+	-	-	-	-	-	-	BPO+	ACD/MI
20	B	M	54	-	12.6	10.5	+	+	lamination	do not know	temporal eczema	-	-	+	-	-	-	-	PTBC+	ACD
21	B	F	53	-	1.6	0.3	+	+	glass fibre mat cutting	glass fibre	continuous eczema		+	+	-	-	-	+(foot)	N.E.	dust+ ACD/MI
22	B	M	31	urticaria	5	0.2	+	+	cutting and grinding	glass fibre, dust	continuous itching		+	-	-	-	+	-	-	all negative MI

N.E., not examined. BPO, bezoyl peroxide. MEKPO, methyl ethyl ketone peroxide. PTBC, *para-tertiary* butylcathecol. ACD, allergic contact dermatitis. ICD, irritant contact dermatitis. MI, dermatitis due to mechanical irritation.

*Period of exposure: duration (years) of FRP factory employment.

**Period to onset: duration (years) from starting to work in FRP factory to the onset when skin problems occurred for the first time.

***Exposure: experience in the lamination and/or postlamination (cutting, grinding and assembling cured plastics) process since commencement of FRP manufacturing.

Table 4. Patch test materials and summary of results

Substance	Concentration	<i>n</i> = 22 with history of skin problems		<i>n</i> = 7 without history of skin problems	
		factory A (<i>n</i> = 18)	factory B (<i>n</i> = 4)	factory A (<i>n</i> = 5)	factory B (<i>n</i> = 2)
<i>Provided by factories</i>					
UP resin (a)	5% pet.	2	NT	0	NT
UP resin (a')	5% pet.	2	NT	0	NT
UP resin (b)	5% pet.	0	NT	0	NT
UP resin (b')	5% pet.	0	NT	0	NT
gloves (a) inner side	as is	0	NT	0	NT
gloves (a) outer side	as is	0	NT	0	NT
dust of factory A	as is	0	NT	0	NT
UP resin (c)	5% pet.	NT	0	NT	0
UP resin (d)	5% pet.	NT	0	NT	0
gloves (b) outer side	as is	NT	0	NT	0
gloves (b) inner side	as is	NT	0	NT	0
dust of factory B	as is	NT	1	NT	0
<i>Possible allergens</i>					
high ammoniated latex	as is	0	0	0	0
thiuram mix	1.25% pet.	0	0	0	0
black rubber mix	0.6% pet.	0	0	0	0
mercapto mix	2% pet.	0	0	0	0
cobalt chloride	1% pet.	6	0	0	0
styrene*	1% pet.	0	1	0	0
hydroquinone	5% pet.	0	0	0	0
PTBC**	1% pet.	1	1	1	0
diethylaniline*	1% alc.	0	0	0	0
benzophenone*	2% pet.	0	0	0	0
benzotriazole**	1% pet.	0	0	0	0
MEKPO*	0.5% pet.	3	1	1	0
BPO	5% pet.	4	1	0	0
methyl methacrylate	2% pet.	0	0	0	0
(2-hydroxyethyl) methacrylate	1% pet.	0	0	0	0
ethyleneglycole dimethacrylate	2% pet.	0	0	0	0
triethyleneglycol dimethacrylate	2% pet.	0	0	0	0
BIS-GMA	2% pet.	0	0	0	0
diurethane dimethacrylate	2% pet.	0	0	0	0
di- <i>n</i> -butylphthalate	5% pet.	0	0	0	0
tricresyl phosphate	5% pet.	0	0	0	0
triphenyl phosphate	5% pet.	0	0	0	0
dimethyl phthalate	5% pet.	0	0	0	0
di-2-ethylhexyl-phthalate	5% pet.	0	0	0	0
rosin (colophony)	20% pet.	0	0	0	0
<i>para</i> -tertiary-butylphenol form-	1% pet.	0	0	0	0
aldehyde resin					
bisphenol A	1% pet.	0	0	0	0
formaldehyde (in water)	1% pet.	1	0	0	0
epoxy resin	1% pet.	0	0	0	0

*4 chemicals were obtained from Nacalai Tesque and prepared in a laboratory. **2 allergens were obtained from Chemotechnique Diagnostics AB. All the other allergens are obtained from Trolab.

Number is the total number of subjects showing + and ? + 0.

NT, not tested. pet., petrolatum. alc., 70% alcohol. PTBC, *para*-tertiary-butyl catechol. MEKPO, methyl ethyl ketone peroxide. BPO, benzoyl peroxide. BIS-GMA, 2, 2-bis[4- (2-hydroxy-3-methacryloxypropoxy)phenyl]propane.

for reinforcement. All hardeners used in both factories were MEKPO complexes. Factory A used an accelerator, the main ingredient of which was cobalt naphthenate. Both factories provided their workers with NRL gloves.

A comparison of work-related exposure factors between patch test survey participants (*n* = 29) and non-participants (*n* = 119) is shown in Table 1. The participants had a longer average exposure time (*p* < 0.001) and a higher proportion (*p* < 0.05) of

workers with a history of work-related skin symptoms than non-participants. All the participants had been involved in the lamination processes since they started in FRP manufacturing.

Table 3 shows the characteristics and patch test results of the 22 subjects with a history of work-related skin problems. Eczema was observed on the hands of 3 workers (case nos. 1, 2 and 14) and on the dorsum of the foot of 1 worker (case no. 21) in either the winter or summer field survey. The

median period from the beginning of FRP employment to the onset of a skin problem was 3.5 (0–19.5) years. Of the 22 workers, 4 workers reported a history of urticaria. 11 workers believed that their skin problems were associated with the lamination process and 7 with the postlamination process, 2 claimed both processes and 2 claimed that their skin problems occurred with cutting glass fibre mat. Substances reported as a cause of skin problems (multiple answers) were glass fibre (10 workers), dust (8 workers), gloves (7 workers) and resin (5 workers), while 2 workers answered that they did not know the cause(s) (Table 2).

A summary of the patch test results is shown in Table 4. Of the 22 workers with a history of skin problems, 2 subjects tested positive to both UP resin (a) and UP resin (a'), 6 to cobalt chloride, 5 to benzoyl peroxide, 4 to MEKPO, 2 to PTBC, 1 to styrene, 1 to dust and 1 to formaldehyde. In total, 16 workers were found positive to at least 1 of the tested substances. Of these, 5 workers showed multiple positive reactions (2 subjects positive to UP resin and cobalt chloride, 1 to formaldehyde and MEKPO, 1 to BPO and MEKPO and 1 to BPO, MEKPO and styrene). Of the 7 workers without a history of skin problems, 1 worker showed a positive reaction to BPO and 1 to PTBC.

According to the diagnostic criteria, 7 workers were diagnosed with ACD, 9 with ACD and/or MI, 3 with ICD and 3 with MI.

Patch test for 2 cases of ACD from UP resin

Both subjects (case nos. 1 and 2) showed positive results (+) to UP base resin (a and a'). They did not show any allergic reaction to the 4 major components, MAn, PAn, diethylene glycol and DCPD, except that case 1 was ?+ to MAn.

Discussion

Patch tests were performed on 29 FRP workers with and without experience of skin problems. Very few reports of the results of patch tests with chemicals of UP systems in a cluster of FRP workers were found, except Tarvainen *et al.* (1) and Malten *et al.* (3). This survey showed that accelerator (cobalt), peroxides (MEKPO and BPO), inhibitor (PTBC) and UP base resin are the chemicals that most frequently sensitized FRP workers who had used UP resin. 18 of the total of 29 participants in FRP factories (62.1%) were sensitized to at least 1 chemical. 16 of 22 workers who had a history of skin problems (72.7%) were sensitized. Considering that 2 of 7 subjects without any history of skin problems had allergic reactions to chemicals and that most of the workers diagnosed

with ACD were free from eczema in the surveys, sensitization did not always lead to the development of eczema in this study.

7 workers were diagnosed with ACD and 9 with ACD or/and MI. Skin injury due to MI by dust can increase the risk of developing ICD and of being sensitized by chemicals and developing ACD, because absorption of chemicals through damaged skin is greater than through intact skin. The field survey showed that FRP workers working in factories in which dust-generating sites were located in a different building from the lamination site had fewer reported histories of work-related skin symptoms than those working in factories where the 2 sites were located in the same building (22). The less chance of exposure to both dust and chemicals at the same time that FRP workers have, the less frequently both ICD and ACD occurred among them.

2 subjects (case nos. 1 and 2) showed positive results to 2 kinds of UP resin (a and a') resin, UP base resin (a and a') and cobalt chloride. Allergens from UP resin can be base resin, styrene or auxiliary agents. UP resin (a) and UP resin (a') consist of the same base resin, whose components are MAn, PAn, ethylene glycol and DCPD, but of different structure and at different concentrations. Case no. 1 showed positive reactions to UP base resin (a and a') and some positive results to MAn. Case no. 1 was examined by further patch testing and showed a strong allergic reaction to fumaric acid (FA), an intermediate chemical in the UP resin condensation process (25). MAn was revealed to cross-react with FA. However, FA did not appear to be an allergen in UP base resin (a and a') by selected ion monitoring method of gas chromatograph-mass spectrometry. Consequently, the allergen in the UP base resin (a and a') of the 2 subjects was thought to be an intermediate or by-product of the condensation process of UP base resin rather than FA.

6 subjects, including cases nos. 1 and 2, showed positive reactions to cobalt chloride. In FRP manufacturing, sensitization to cobalt can occur due to either cobalt octate or cobalt naphthenate used as an auxiliary ingredient in UP resin or added as an accelerator to UP resin in the lamination process. In this survey, cobalt chloride was the most common sensitizer. However, cobalt is 1 of the allergens that causes a positive reaction most frequently among the general Japanese population. 18.4% of Japanese patients ($n=1258$) who consulted a dermatologist and were tested with the Japanese standard series were reported to be sensitized to cobalt chloride, though 80% of these subjects were female (26). Sensitization occurs in daily life in reaction to cobalt in alloys, hair dyes, ce-

ment, paints, crayons, etc. (2). In this survey, 20.7% (6/29) of the workers showed positive reactions to cobalt chloride. Whether cobalt sensitization actually occurred during FRP work remains to be investigated.

MEKPO was the main ingredient of the hardener used in the 2 factories. MEKPO as well as styrene can be a major cause of ICD and chemical burn (8). In this survey, 4 subjects showed positive results to MEKPO. MEKPO sensitization cannot occur in the everyday environment, and was particularly present among FRP workers.

BPO is also commonly used as a hardener for UP resin but was not used in the 2 factories when the survey was undertaken. Even so, 5 subjects showed positive reactions to BPO, 1 of whom showed a positive reaction to MEKPO at the same time. The 2 peroxides can cross-react in patch tests (16). Sensitization to BPO can occur from non-occupational exposures such as exposure to adhesive tape (18), medical prostheses (19) or medical preparations for acne or ulcers (20, 21). In Japan, the medical use of BPO is not approved, so sensitization in daily life is rarer than in countries where BPO is used on the skin as a medical preparation. Sensitization thus probably occurred from previous exposure in FRP manufacturing.

PTBC is used in UP resin as an inhibitor at concentrations as small as 0.005% (12). In total, 3 subjects reacted positively to PTBC. PTBC is a rare allergen that is used in the rubber, paint and petroleum industries as well as in UP systems (13). The 3 subjects had no other history of exposure to the chemical prior to their FRP factory employment. It is surprising that PTBC was a quite frequent sensitizer given the small amount used.

7 workers answered that their skin problems were due to gloves. Gloves used in the 2 factories were made of NRL. Immediate-type latex allergy by prick test has been reported (1), but no study of delayed-type allergy to NRL among FRP factory workers could be found. In this survey, all of the workers showed negative reactions to NRL gloves, high ammoniated latex sheet and rubber chemicals. Although the workers thought that gloves caused dermatitis, the dermatitis might actually have been due to glove contamination by chemicals, glass fibre and/or dust. This survey did not include a prick test for immediate-type latex allergy.

Dust comprises plastic particles and fragmented glass fibre. Both components can cause mechanical irritation, leading to itching and eczema (27–29). Positive reactions to dust can include ACD due to cured plastics or MI due to both components of dust. The skin condition of case no. 21, who showed a positive reaction to dust, was eczema on

the dorsum of the foot; the worker mainly complained of continuous itching due to glass fibre. Consequently, case no. 21 was diagnosed as ACD and/or MI.

Most of the workers with a history of skin problems complained of summer exacerbation. It was eventually observed that the 2 ACD cases due to UP base resin and cobalt (cases 1 and 2) developed eczema only in the summer. The reason why the 2 individuals could continue to work, even though they had continuously had skin problems for years, was that they could control the problem with the proper protection of the skin that was possible in wintertime. In summer, the workers were working in an adverse environment of high temperature and humidity without any air conditioning.

To avoid sensitization, adequate skin protection is required at the commencement of FRP work. In the questionnaire survey of 148 workers, 13 of the 87 workers reporting a history of skin problems indicated that they started wearing gloves only after encountering skin problems (22). We previously reported an ACD case in an individual who was sensitized to cobalt, MEKPO and acrylates because he did not use gloves despite easy access to gloves in his FRP factory (17). Education about the benefits of skin protection, i.e. that gloves can prevent sensitization, is needed at the commencement of employment. In addition, the results from this survey suggest that proper protection of skin might enable sensitized workers to continue to work in FRP factories.

Acknowledgements

The co-operation of the managers and workforce of the 2 FRP factories is greatly appreciated. Sincere thanks to Dr Atsushi Ueda and Dr Koichi Harada, Department of Hygiene, Kumamoto University School of Medicine, for valuable advice.

References

1. Tarvainen K, Jolanki R, Forsman-Grönholm L et al. Exposure, skin protection and occupational skin diseases in the glass-fibre-reinforced plastics industry. *Contact Dermatitis* 1993; 29: 119–127.
2. Rietschel R L, Fowler J F. *Fisher's Contact Dermatitis*, 4th edn. Baltimore: Williams & Wilkins, 1995.
3. Malten K E, Zielhuis R L. Unsaturated polyesters. In: *Industrial Toxicology and Dermatology in the Production and Processing of Plastics*. Amsterdam: Elsevier, 1964: 71–84.
4. Tarvainen K, Jolanki R, Estlander T. Occupational contact allergy to unsaturated polyester resin cements. *Contact Dermatitis* 1993; 28: 220–224.
5. Kanerva L, Estlander T, Alanko K, Pfaffli P, Jolanki R. Occupational allergic contact dermatitis from unsaturated polyester resin in a car repair putty. *Int J Dermatol* 1999; 38: 447–452.

6. Lidén C, Löfström A, Storgårds-Hatam K. Contact allergy to unsaturated polyester in a boat builder. *Contact Dermatitis* 1984; 11: 262–264.
7. Dooms-Goossens A, De Jonge G. Letters to the editor. *Contact Dermatitis* 1985; 12: 238.
8. Bourne L B, Milner F J M. Polyester resin hazards. *Br J Ind Med* 1963; 20: 100–109.
9. Schena D, Rosina P, Chierigato C, Colombari R. Lymphomatoid-like contact dermatitis from cobalt naphthenate. *Contact Dermatitis* 1995; 33: 197–198.
10. Wahlberg J E, Wrangsjö K. Is cobalt naphthenate an allergen? *Contact Dermatitis* 1985; 12: 225.
11. Bedello P G, Goitre M, Alovizi V, Cane D. Contact dermatitis caused by cobalt naphthenate. *Contact Dermatitis* 1984; 11: 247–264.
12. Freeman S. Contact dermatitis of a limb stump caused by p-tertiary butyl catechol in the artificial limb. *Contact Dermatitis* 1986; 14: 68–69.
13. Estlander T, Kostianen M, Jolanki R, Kanerva L. Active sensitization and occupational allergic contact dermatitis caused by para-tertiary-butylcatechol. *Contact Dermatitis* 1998; 38: 96–100.
14. Sjöborg S, Dahlquist I, Fregert S, Trulsson L. Contact allergy to styrene with cross reaction to vinyltoluene. *Contact Dermatitis* 1982; 8: 207.
15. Bhushan M, Craven N M, Beck M H. Contact allergy to methyl ethyl ketone peroxide and cobalt in the manufacture of fibreglass-reinforced plastics. *Contact Dermatitis* 1997; 39: 203.
16. Stewart L, Beck M H. Contact sensitivity to methyl ethyl ketone peroxide in a paint sprayer. *Contact Dermatitis* 1992; 26: 52–53.
17. Minamoto K, Nagano M, Inaoka T, Futatsuka M. Allergic contact dermatitis due to methyl ethyl ketone peroxide, cobalt naphthenate and acrylates in the manufacture of fibreglass-reinforced plastics. *Contact Dermatitis*, in press.
18. Greeiner D, Weber J, Kaufmann R, Boehncke W H. Benzoyl peroxide as a contact allergen in adhesive tape. *Contact Dermatitis* 1999; 41: 233.
19. Vincenzi C, Cameli N, Vassilopoulou A, Tosti A. Allergic contact dermatitis due to benzoyl peroxide in an arm prosthesis. *Contact Dermatitis* 1991; 24: 66.
20. Agathos M, Bandmann H J. Benzoyl peroxide contact allergy in leg ulcer patients. *Contact Dermatitis* 1984; 11: 316–317.
21. Lindemayr H, Drobil M. Contact sensitization to benzoyl peroxide. *Contact Dermatitis* 1981; 7: 137–140.
22. Minamoto K et al. Skin problems among fibreglass-reinforced plastics factories workers. *Ind Health* 2002; 40: 42–50.
23. Pirilä V. Chamber test versus patch test for epicutaneous testing. *Contact Dermatitis* 1957; 2: 252–255.
24. Wilkinson D et al. Terminology of contact dermatitis. *Acta Derm-Venerol* 1970; 50: 287–292.
25. Minamoto K, Nagano M, Yonemitsu K, Futatsuka M. Allergic contact dermatitis from unsaturated polyester resin consisting of maleic anhydride, phthalic anhydride, ethylene glycol and dicyclopentadiene. *Contact Dermatitis*, in press.
26. Mitsuya K. A multiple survey of patch-testing with Japanese standard series, topical steroid preparations (budesonide, amcinide and hydrocortisone butyrate) and tin chloride (0.5%, 1.0% and 2.0% pet) in 1997. *Environ Dermatol* 1999; 6: 199–208.
27. Possick P A, Gellin G A, Key M M. Fibrous glass dermatitis. *Am Ind Hyg Assoc J* 1970; 12–15.
28. Björnberg A. Glass fiber dermatitis [Review]. *Am J Ind Med* 1985; 8: 395–400.
29. Breum N O, Pock-Steen B, Laursen K, Gyntelberg F. Epidemic itching due to dust. *Contact Dermatitis* 1986; 14: 117–118.

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