

Recent Statistics on Contact Allergy to Epoxy Compounds – Investigation of Patients Exposed to Complex Epoxy Products

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Background. About 600 patients were investigated at the FIOH for suspected occupational dermatitis in October 2002 – February 2006. The objective of the study was to analyze the recent results of patch tests to epoxy compounds. In addition, the dermatitis investigations on three patients exposed to complex epoxy products are described.

Methods. The study population consisted of 113 patients patch tested with the epoxy resin series (Table 1, test substances nos. 1–31). All of our patients were tested with the modified standard series which included two epoxy resin test substances (Table 1, nos. 32–33) and, as usual, also with the patients' own materials that they used at work.

Patch tests were performed according to the recommendations of the International Contact Dermatitis Research Group, using Finn Chambers and an application time of 48 hours. The tests were read on D2-(D3)-D4/5/6, depending on the day of the week when the test patches were removed.

Acetone-soluble epoxy compounds were analyzed by gas chromatography with mass spectrometric detection. The content of tetraglycidyl-4,4'-methylene-dianiline (TGMDA, CAS 28768-32-3) was determined by liquid chromatography with UV detection.

Patch Test Results. 37 patients had no test reactions to the epoxy compounds, 35 had only irritant reactions and 41 displayed allergic reactions (Table 1). The diagnoses of the patients who developed allergic test reactions to epoxy compounds were as follows: occupational allergic contact dermatitis (ACD) in 32 patients, and occupational irritant contact dermatitis in 3 patients; occupational skin disease was not found in 6 patients.

The highest number of allergic reactions was caused by diglycidyl ether of bisphenol-A (DGEBA) epoxy resin (24 reactions), DGE of bisphenol-F (DGEBF) epoxy resin (19 reactions), and brominated epoxy resin, which contains 19% DGEBA (22 reactions). Of the reactive diluents, 1,4-butanedioldiglycidylether and phenylglycidylether, and of the hardeners, m-xylylenediamine, induced allergic reactions most frequently (9 reactions each).

N,N-Diglycidyl aniline (DGA) at 1% in pet gave 42 irritant or questionable reactions, and triglycidyl-p-aminophenol (TGPAP) at 0.25% in pet gave 36 irritant or questionable reactions.

Case Reports. Patient 1 is a car painter. Patch testing with the epoxy compounds and 21 materials used at work revealed contact allergy to DGA and to four car lacquers at 5% in pet. According to the safety data sheets (SDS), three lacquers contained glycidyl neodecanoate (CAS 26761-45-5). In chemical analyses, none of the lacquers contained DGA (detection limit 0.002%), but the concentration of glycidyl neodecanoate ranged from 0.5% to 2.3%. During 1984–1988 Cardura E10 has been tested at 0.25% in pet in 39 patients with negative results; thereafter the test substance was removed from our test series. In patch testing, the patient with two Cardura E10 products containing mainly glycidyl neodecanoate showed 2+ and 1+ reactions at 1% pet, ?+ and 1+ reactions at 0.32% pet, and negative and ?+ reactions at 0.1% pet, respectively. This was the first case of occupational contact allergy caused by this chemical, encountered at FIOH. The diagnosis of Patient 1 is occupational ACD from glycidyl neodecanoate in car lacquers.

Patient 2 is a worker in the aircraft industry. At patch testing he got allergic test reactions to DGA and TGPAP. With the test substances prepared from 22 materials used at work, he developed allergic reactions to one epoxy resin at 1% and 2% in pet and to two sealants at 5% pet. In chemical analyses, the epoxy resin product was found to contain 23% TGPAP and 0.1% DGA, whereas the sealants did not contain the chemicals (detection limit 0.003%). According to the SDSs, the sealants contained 30–70% aliphatic polysulfide polymer (PSP, CAS 68611-50-7). Two aliphatic PSPs were

Table 1. Test substances in patch testing of patients exposed to epoxy compounds at FIOH, and results of 41 patients with contact allergy.

No.	Test substance (manufacturer in parentheses)	% in pet	No. of patients tested	Allergic reactions (1+, 2+, 3+)
<i>Non-DGEBA epoxy resins and reactive diluents</i>				
1.	Diglycidylhexahydrophthalate (O)	1	113	2
2.	Cycloaliphatic epoxy resin (C)	0.5	113	-
3.	Quetol 651 (ethyleneglycoldiglycidylether) (O)	0.5	113	-
4.	DEG diluent (diethyleneglycoldiglycidylether) (O)	0.5	113	-
5.	DER 736 (tetrapropylenglycoldiglycidylether) (O)	0.5	113	2
6.	Rütapox 0451 (brominated DGEBA epoxy resin) (O)	1	113	22
7.	ERL 4221 (cycloaliphatic epoxy resin) (O)	1	113	-
8.	ERL 4206 (vinyl cyclohexene diepoxide) (O)	0.5	113	1
9.	N,N-Diglycidyl aniline (DGA) (O)	1	113	4
10.	Triglycidyl-p-aminophenol (TGPAP) (O)	1/0.25	5/108	1/8
11.	1,4-Butandiol diglycidylether (O)	0.25	113	9
12.	Phenylglycidylether (C)	0.25	113	9
13.	Cresylglycidylether (T)	0.25	113	3
<i>Hardeners</i>				
14.	Ethylenediamine dihydrochloride (T)	1	113	1
15.	Diethylenetriamine (T)	0.5	113	-
16.	Triethylenetetramine (T)	0.5	113	-
17.	Tetraethylenepentamine (O)	1	113	-
18.	Trimethylhexamethylenediamine (O)	1	113	1
19.	Hexamethylenetetramine (T)	1	112	1
20.	Isophoronediamine (T)	0.5	113	3
21.	m-Xylylenediamine (O)	1	113	9
22.	2,4,6-tris-(Dimethylaminomethyl)phenol (O)	1	113	4
23.	N(3-Dimethylaminopropyl)-1,3-propylenediamine (O)	1	113	-
24.	3-Dimethylaminopropylamide (O)	1	113	1
25.	Methylhexahydrophthalic anhydride (O)	1	113	-
26.	Triglycidyl isocyanurate (polyester hardener) (C)	0.5	113	-
<i>Raw materials of DGEBA epoxy resins</i>				
27.	Bisphenol A (T)	1	112	-
28.	Epichlorohydrin (B/O)	0.1	40/73	-
<i>Epoxy (meth)acrylates</i>				
29.	Epoxy diacrylate (C)	0.5	113	1
30.	Bis-GMA (T)	2	113	1
31.	Glycidyl methacrylate (O)	0.1	113	3
<i>Epoxy resins in FIOH's standard series</i>				
32.	DGEBA epoxy resin (T)	1	113	24
33.	DGEBF epoxy resin (O)	1/0.25	98/15	18/1

O = prepared at FIOH

C = Chemotechnique Diagnostics, Malmö, Sweden

T = Trolab, Hermal, Reinbeck, Germany

B = Brial allergen GmbH, Greven, Germany

purchased from the manufacturer for additional patch testing. In the patch tests, the PSPs gave allergic reactions to the patient at 5% and 1.6% in pet. Control tests in 20 patients at 5% and 1.6% were all negative. Our patient obviously had contact allergy to TGPAP, DGA and aliphatic PSP. The primary diagnosis of Patient 2 is occupational ACD from TGPAP and DGA in the epoxy resin product, and the secondary diagnosis is occupational ACD from aliphatic PSPs in sealants.

Patient 3 was also a worker in the aircraft industry. At patch testing with the epoxy compounds, he showed one faint test reaction to TGPAP at 0.25% pet. Test substances prepared from 17 materials used at work gave him allergic reactions to two epoxy resin products at 5–0.5% in pet. In chemical analyses, the patient's own epoxy resin products did not contain TGPAP (detection limit 0.001%), whereas one contained 61% DGEBA and the other 34%. According to the amended SDSs, the two epoxy resin products contained also TGMDA, and according to the analyses, the amounts were 25% and 54%. Uncured composite material (prepreg) used at the workplace was found to contain 10.5% TGMDA, and the sanding dust of cured composite material 0.075% TGDMA. Patch testing with TGMDA at 1%, 0.32% and 0.1% in pet gave 2+ reactions, at 0.032% in pet a 1+ reaction, and at 0.01% a ?+ reaction. Control tests in 5 patients at 0.5% and 0.25% in pet were all negative. Patient 3 had occupational contact allergy only to TGMDA. The diagnosis of Patient 3 is occupational ACD from TGDMA in epoxy resin products and composite materials.

Discussion. Patient 1 was the first patient at FIOH who obviously had allergic contact dermatitis due to glycidyl neodecanoate from car lacquers. The reactive diluent, usually called Cardura E10, is evidently a very rare contact allergen, because only two case reports have previously been published [1, 2].

There are several earlier case reports of contact allergy from PSP sealants [3–9], but Patient 2 was the first patient sensitized to PSP investigated at FIOH. To our knowledge, aliphatic PSPs in their pure form have not been tested previously.

There are a very few previous case reports in the published literature on TGMDA [10, 11]. A few previous cases have also been encountered at FIOH [12], but not in recent years.

TGMDA is probably a highly sensitizing chemical, because Patient 3 was simultaneously strongly exposed to both DGEBA epoxy resin and TGMDA, but developed contact allergy only to TGMDA. Later, a few other men at the same workplace were also found to be sensitized to TGMDA.

Practical Conclusions. The patch test concentrations of DGA and TGPAP were lowered to 0.1% in pet. Cardura E10 1% at pet, aliphatic PSP at 1% in pet and TGMDA at 0.25% in pet were added to the epoxy resin series.

Testing with non-DGEBA epoxy resins, hardeners and reactive diluents is beneficial in some complicated cases. It is important to perform the tests also with the materials handled at work. Testing of the ingredients may verify the identification of the new allergen.

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