OCCUPATIONAL DERMATITIS FROM A ONE-COMPONENT NAPHTHALENE TYPE EPOXY ADHESIVE

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Abstract: In an electronics plant, a new one-component naphthalene type epoxy resin was used as an adhesive for reinforcing a circuit board. The resinous part of the adhesive consisted of diglycidyl ether of bisphenol A (DGEBA) and 1,6-bis(2,3-epoxypropoxy)naphthalene type epoxy resins. The hardener was methylhexahydrophthalic anhydride (MHHPA). Of 54 workers, 15 (27.8%) were diagnosed to have work-related dermatitis but were not patch tested. Therefore, it was impossible to determine the specific agent responsible for the worker’s symptoms or to distinguish between allergic and irritant contact dermatitis. They worked without protective gloves until they started to develop skin symptoms. The hands were the commonly affected region (13 out of 15 cases). The latent period of dermatitis was very short (mean 2.2 weeks). Of these, 10 cases (66.7%) received medication for dermatitis, and 9 cases (60%) were transferred to other work. The work-related skin symptoms were closely related to the specific tasks, i.e., filling dispensers with the adhesive and manual application of the adhesive to a portion of a circuit board using a dispenser. For occupational hygiene reasons, contact with epoxy resins should be minimized by taking all possible measures into use, including protective gloves. Further studies are required to clarify the allergenicity of 1,6-bis(2,3-epoxypropoxy)naphthalene, since very little is known about the mechanism through which it leads to the symptoms of dermatitis.

Key words: Contact dermatitis, A one-component epoxy adhesive, 1,6-Bis(2,3-epoxypropoxy)naphthalene, Diglycidyl ether of bisphenol A

Since epoxy resins have good adhesive strength, electrical insulation, and chemical resistance, they are widely used in adhesives, coatings, materials for molds and composites, and encapsulation. On the other hand, epoxy resin compounds include a large number of sensitizing chemicals such as epoxy resins, hardeners (curing agents), and reactive diluents1). The health hazards caused by epoxy resins are often occupational. Most occupational exposures occur in the manufacturing process by the inhalation of chemical vapors and airborne dust or direct skin contact, and the most frequent adverse effects arise from irritation or allergic mechanisms involving the dermal or respiratory systems1, 2). Consideration of health effects must encompass an entire epoxy resin system with its potentially vast number and combinations of chemicals. To our knowledge, this is the first report on occupational dermatitis caused by a one-component epoxy adhesive Ohmcoat 1572 (Namics Co., Niigata, Japan) using 1,6-bis(2,3-epoxypropoxy)naphthalene (naphthalene type epoxy resin, Fig. 1) as the major resinous part.

Early in June 2001 we received a request from plant management for assistance regarding skin problems among workers at a plant that manufactures personal data assistants. Skin complaints were first recognized at the beginning of May, 2001. A visit was immediately made to the workplace; it became evident that the tools and workbench were contaminated by liquid epoxy resin and that protective gloves were not used during different direct epoxy resin handling operations. In response, we performed our investigation around the middle of June. During April-June of 2001, a

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A total of 54 workers took part in the work of coating a portion of a circuit board with a one-component epoxy adhesive for reinforcements. This work included the following processes: (1) automatic application of the adhesive using coating machines; (2) filling dispensers with the adhesive; (3) manual application of a second coat on top of the first, using a dispenser; (4) stacking of coated boards; (5) transport of the latter to a curing oven (150°C), where the resin dries and polymerizes; (6) carrying out electrical tests on the boards. The 54 workers were assigned to one or more of the above activities (filling, coating, repacking, transport, and inspection). The subjects consisted of 5 male and 49 female workers, ranging in age from 18 to 31 (mean ± SD, 21.7 ± 3.0) years. None of the subjects had previous contact with epoxy resins in the workplace. The following epoxy adhesive was used as a reinforcement: Ohmcoat 1572 (a black viscous liquid). According to the material safety data sheet, the respective amounts of the ingredients are shown in Table 1. The amount used in a month was about 40 kg.

Of the 54 workers, 6 (11.1%) suffered from mild dermatitis (itching papules or itching red skin), and 9 (16.7%) from severe dermatitis (itching red papulous and vesicular skin). They worked without protective gloves until they started to develop skin symptoms. The hands were the commonly affected region (13 of 15 cases: 86.7%), followed by the face (60%), wrists (46.7%), forearms (26.7%), neck (13.3%), and legs (6.7%). The upper limb was involved in all of the cases. The mean period between starting work and the occurrence of dermatitis was 2.2 (range 1–4) weeks. Of these, 10 cases (66.7%) received medication for dermatitis, and 9 cases (60%) were transferred to other work, indicating that their symptoms were very intolerable. As shown in Table 2, the frequency of work-related dermatitis in the repacking and/or inspection, leaders, and coating groups was 1/32 (3.1%), 3/5 (60%), and 11/17 (64.7%), respectively. A significant overall trend was observed across the groups according to main job, although the difference between the leaders and coating groups did not achieve statistical significance. The leaders and coating groups had plenty of chances to handle the uncured adhesive directly, whereas the repacking and/or inspection group never handled. At the time of examination, it was confirmed that the symptomatic workers often had epoxy resin exposure via skin contact during the coating and filling processes, except one worker in the repacking and/or inspection group.

**Table 1. Hazardous chemicals of the epoxy adhesive Ohmcoat 1572, according to the material safety data sheet**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>DGEBA-based epoxy resin (CAS 25068-38-6)</td>
<td>10%</td>
</tr>
<tr>
<td>1,6-Bis(2,3-epoxypropoxy)naphthalene (CAS 27610-48-6)</td>
<td>30–40%</td>
</tr>
<tr>
<td>MHHPA (CAS 25550-51-0)</td>
<td>45–55%</td>
</tr>
</tbody>
</table>

DGEBA; diglycidyl ether of bisphenol A. MHHPA; methylhexahydrophthalic anhydride.

**Table 2. The relation between work-related dermatitis and various jobs in a group of 54 workers**

<table>
<thead>
<tr>
<th>Exposed workers</th>
<th>Symptomatic (n=15)</th>
<th>Nonsymptomatic (n=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>main job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>repacking and/or inspection</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>leaders</td>
<td>3*</td>
<td>2</td>
</tr>
<tr>
<td>coating</td>
<td>11**</td>
<td>6</td>
</tr>
</tbody>
</table>

Differences among groups were analyzed by Fisher’s exact test and by Bonferroni’s method. *, **Significant vs repacking and/or inspection (*p<0.005, **p<0.0001).
worker’s dermatitis may have appeared on the hands due to epoxy contamination of the workbench. It is thought that workers had been exposed to the uncured adhesive more frequently because of their ignorance about hazards of occupational chemicals. Hence, prevention of contact dermatitis due to epoxy resins requires through education of workers about careful handling, with repeated emphasis on the hazards of using epoxy resins as adhesives.

Ohmcoat 1572 is a mixture of diglycidyl ether of bisphenol A (DGEBA) and naphthalene type epoxy resins; its hardener is methylhexahydrophthalic anhydride (MHHPA). MHHPA is by far the leading cause of epoxy-related immunologically mediated respiratory disease such as asthma1–3). MHHPA levels in the air were determined by area sampling on silica gel tubes: the anhydride was analyzed by gas chromatography with electron-capture detection after derivatization4). Air samples taken from 5 representative points in the workplace all contained a MHHPA level below the detection limit, i.e., less than 1 µg/m³. MHHPA vapors did not leak out of the curing oven. Therefore, no subject has yet developed respiratory symptoms suspected to be related with that work.

Both MHHPA and DGEBA-based epoxy resins have generally similar skin irritancy (primary cutaneous irritation (PCI) index = 0–2; classified as a weak irritant)5). MHHPA rarely if ever causes allergic contact dermatitis3), while DGEBA-based epoxy resins are the most common causes of occupational allergic contact dermatitis2, 6). On the other hand, to our knowledge, contact dermatitis from naphthalene type epoxy resin has not previously been reported. Naphthalene type epoxy resin belongs to a group of non-DGEBA-based epoxy resins, which are also strong contact sensitizers2, 7). According to the technical data on 1,6-bis(2,3-epoxypropoxy)naphthalene (Dainippon Ink and Chemicals Inc., Japan), the guinea pig maximization test was positive and the PCI index was 4.0–5.9 on the basis of the OECD protocol, suggesting that it is a compound that strongly irritates and sensitizes the skin. Hence, it is highly probable that the causes of work-related dermatitis were naphthalene type and/or DGEBA-based epoxy resins. However, it cannot be denied that MHHPA was also the causative agent, since one case of delayed and immediate-type allergic skin reactions to MHHPA has been reported8). In the present study, it was impossible to determine the specific agent responsible for the worker’s symptoms or to distinguish between allergic and irritant contact dermatitis, because no patch tests were performed. Since very little is known about occupational dermatitis due to 1,6-bis(2,3-epoxypropoxy)naphthalene, further studies, including patch testing, are required to clarify the mechanism through which it leads to the symptoms of dermatitis.

References