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FORMALDEHYDE AS A CONTACT ALLERGEN IN TEXTILES

*Formaldehyde Clothing Dermatitis. A Ten Year Period
in-patient Series (1953-1962)*

By

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Allergic contact dermatitis (eczema) due to formaldehyde in clothing has been noted as an increasing dermatological problem in Scandinavia over the last ten years. The first report came from Norway in 1957, when *Andrup* (1) published a series of five cases in which patch tests with water-moistened fabrics were positive in addition to the test with formaldehyde (4 per cent aqueous solution). Patch tests with the textiles themselves often prove negative in this type of clothing dermatitis. This phenomenon may possibly account for the fact that contact eczema due to such a cause has not been recognized as an important problem in some other countries.

Clothing dermatitis due to formaldehyde sensitivity was one of the main topics discussed at the 15th Scandinavian Congress of Dermatology in Oslo (1959). At the meeting valuable contributions to the clarification of this problem were given by *Marcussen* (8), *Skogh* (11), *Hövdning* (6), *Blohm* (2) and others. More recently Professor Marcussen, Copenhagen, has followed up formaldehyde clothing dermatitis in a series of communications (9, 10). In Sweden, attention has been drawn to the eczematogenic role of free formaldehyde in textiles by *Blohm* (3), and from Norway *Hövdning* has described a rising incidence of dermatitis from it.

In Norway, the incidence of allergic contact dermatitis from formaldehyde in clothing has now risen to such a level, particu-

larly in females, that the problem has spontaneously been taken up by the public through the National Consumers' Council and also over the radio and in the public press.

FORMALDEHYDE AND TEXTILE FIBRES

Several kinds of textile fibres used in clothing (especially cotton and rayon) may in different ways be improved in quality by treatment with formaldehyde. Textile manufacturers have known of this since before 1920, but little use was made of the knowledge until about 1940. Formaldehyde amine resins (particularly formaldehyde melamin and formaldehyde urea) are most useful agents for textile "finishing" by which a wide range of quality improving effects may be achieved, well known under such terms as: crease-resistance, water-proofing, better dye absorption, non-shrinkable, moth-proof, anti-swell-ing, non-iron, drip-dry-cotton etc.

These formaldehyde amine resins are "thermosetting", and curing takes place by polymerization, partly by condensation. The curing is affected by interaction of formaldehyde resin molecules, but a polymer—cellulose reaction may also take place by which the cured resin macromolecules are linked directly with the textile fibre. A more comprehensive survey on the chemical and physical aspects of formaldehyde resins in relation to clothing dermatitis is given by *Cronin* (4).

After curing of the resin, some free formaldehyde is likely to persist in the fabric. Textile manufacturers are quite aware of the importance that this free formaldehyde be removed from the fabric by washing. Such washing, however, evidently does not prevent contact dermatitis in susceptible individuals. These usually react with a positive patch test to formaldehyde, whilst they may be negative to patch tests with the resins, and the resintreated material. There seems to be no other explanation for this but the assumption that the resin will slowly break down (depolymerize) while in contact with the body of some individuals, and that this may be facilitated by the sweat and higher temperature of the flexures, such as the axillae. Hence,

the mere label of "free formaldehyde", based on chemical tests, does not determine absolutely whether or not the garment is capable of causing dermatitis.

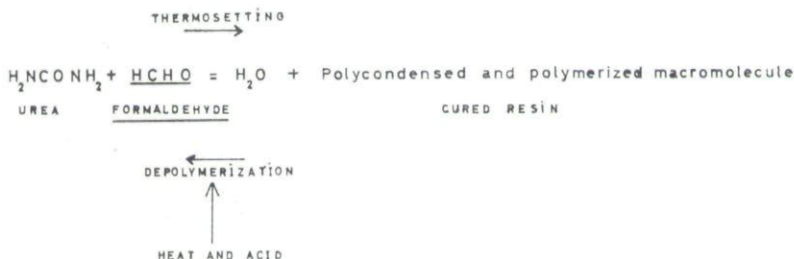


Fig. 1.

Schematic view on the chemistry of a formaldehyde amine resin useful for improving textile fibres.

TESTS FOR DETECTION OF FORMALDEHYDE IN CLOTHING

As the patients' skin in typical cases does not clear up before all skin contact with formaldehyde- or resin-treated clothing is avoided, the exclusion of such garments from the patients' wardrobe is most important for successful treatment and for the later prevention of the dermatitis. Any testing of the textiles has to include both free formaldehyde and resin. The latter may be depolymerized by heating the material in acid solution (Fig. 1), and free formaldehyde thereby released, is easily detectable with a formaldehyde reagent.

The most specific analytical agent for the detection of formaldehyde in clothing is probably purified chromotropic acid. Based on this compound, *Blohm* (2) has suggested a simple test for free formaldehyde gas released from clothing, and *Hövdling* (6) has described a quantitative method for the estimation of formaldehyde in textiles. *Marcussen* (10) at the Finsen Institute, Copenhagen, has introduced a more simple screening procedure, by which the resin is depolymerized by boiling the material in sulphuric acid solution, and the released formaldehyde is detected by a reddish-purple colour reaction

with purified chromotropic acid. This screening test requires the use of a concentrated sulphuric acid solution, which is felt to be somewhat unsafe in the hands of the patient at home. Because of the geographical features of Norway with long distances from many patients' home to the nearest dermatologist, we have chosen the following "Schiff's test" as a routine procedure in spite of its poorer specificity. The latter test is very satisfactorily carried out by many patients themselves at home. The 0.1 normal hydrochloric acid solution used for depolymerization, is believed to carry a smaller risk in the hands of the patient than strong solutions of sulphuric acid.

SCHIFF'S REAGENT METHOD

1. Cut a small strip of material, approximately 1×4 cm (or less).
2. Immerse it in about 5 ml of 0.1 normal hydrochloric acid.
3. Heat in a water bath (temperature $60-80^\circ \text{C}$) for 10 minutes.
4. Add 5 drops of *Schiff's reagent for detection of aldehydes*.
5. A violet colour developing in the course of some minutes indicates the presence of free aldehyde (released from the fabric). In textiles this will almost certainly represent formaldehyde.

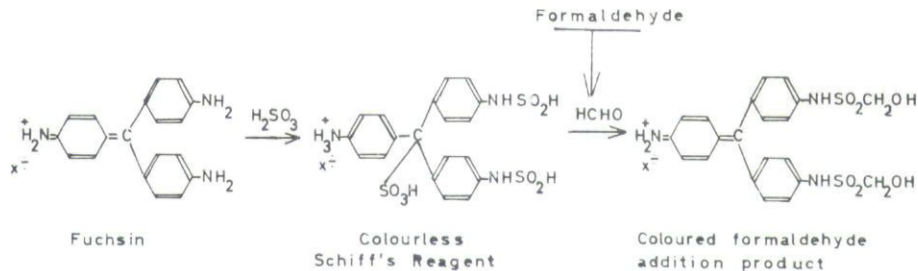


Fig. 2.

The chemistry of Schiff's test for formaldehyde.

(Schiff's reagent for detection of aldehydes may be supplied from the British Drug Houses, Ltd. (Laboratory Chemicals Division). Reagent obtained from this Company has, in the author's hand, proved more effective and more stable than Schiff's reagent made by Norwegian chemists (the Hospital dispensary). The reagent should be stored in a refrigerator, and the glass should have an airtight stopper. Its activity may diminish during storage).

The chemistry of Schiff's test is shown in Fig. 2. The reagent contains decolourized fuchin. Fuchin is a magenta dye, which is decolourized by sulphur dioxide in aqueous solution. If aldehydes are added to the solution, a magenta dye reappears. Heating, alkalis, some amines and prolonged exposure to air may also remove sulphur dioxide and to some extent regenerate the colour of the reagent. In the absence of such interference, however, this reagent is very useful in the detection of aldehydes.

THE PRESENT INVESTIGATION

At the department of Dermatology, Oslo University Hospital (Rikshospitalet), a total of 12,955 *in-patients* with dermatological disorders have been treated during the 10 year period 1953-1962. 2,213 cases, *i.e.* 17.4 per cent out of this *in-patient* series, were diagnosed as *Eczema idiosyncraticum* (Allergic contact dermatitis). Out of this "contact group" 9.7 per cent, *i.e.* 218 cases, are believed to have been *dermatitis precipitated by allergy to formaldehyde in clothing*.

The cases have been evaluated on the basis of the history, localization of the dermatitis, patch tests, and since 1957 in the majority of the cases also by testing strips from patients' clothing with Schiff's fuchsin reagent, and studying the therapeutic effect of excluding "Schiff's positive" garments from the patients' wardrobe.

Clinically, these patients present an eczematous dermatitis at sites where clothing is worn in close contact with the skin. The sites of predilection are those which are most likely to be humid from sweat, as the periaxillary areas. In some cases it is impressive how underclothes (which are seldom resin-treated) have protected certain sites from being involved by the dermatitis.

Females are affected approximately three times as frequently as males in this series. *Out of the 218 cases, 163 were females and 55 were males.* (Cronin, in a series from London, found the ratio females/males to be 5/1 in a total of 30 cases).

The age incidence in the present series is shown in Fig. 3. The incidence for both sexes is recorded separately and is compared with the corresponding age group distribution of allergic

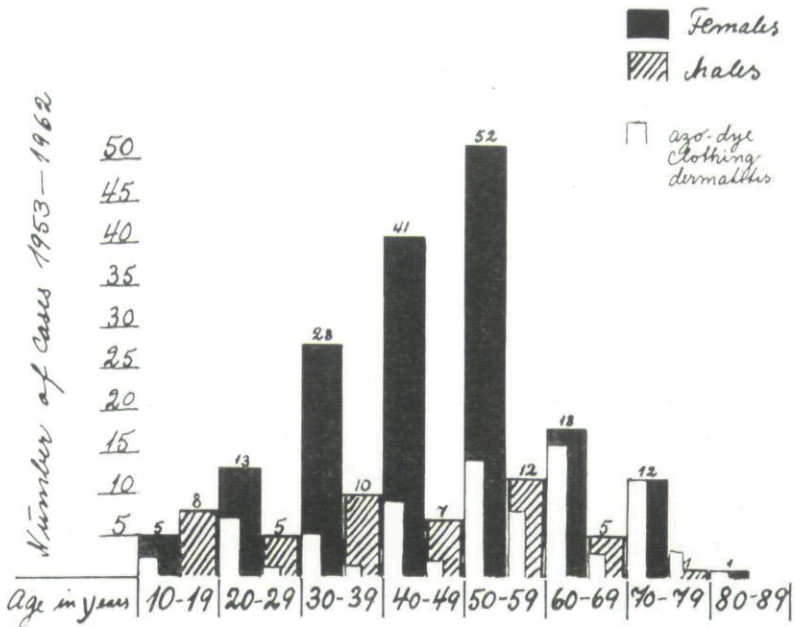


Fig. 3.

Sex and age incidence of formaldehyde clothing dermatitis in in-patients of the 10 year period 1953-62. (For comparison the corresponding incidence of azo dye clothing dermatitis is plotted with more narrow white columns).

contact dermatitis due to sensitivity to azo- or aniline-dyes in clothing during the same 10 year period.

The annual number of formaldehyde clothing cases is shown in Fig. 4, and is also compared with the corresponding incidence of azo- or aniline-dye dermatitis from clothing (the dotted line) throughout the period.

Table 1 shows the annual number of formaldehyde clothing dermatitis in relation to the annual total number of allergic contact cases (eczema idiosyncraticum).

Table 2 shows the annual number of eczematous formaldehyde reactors in the present series, and the relation between the number of positive reactors and the total number of in-patients patch-tested with 4 per cent aqueous solution of formaldehyde.

ECZEMA IDIOSYNCRATICUM (TEXTILE-)

In-patients 1953-1962

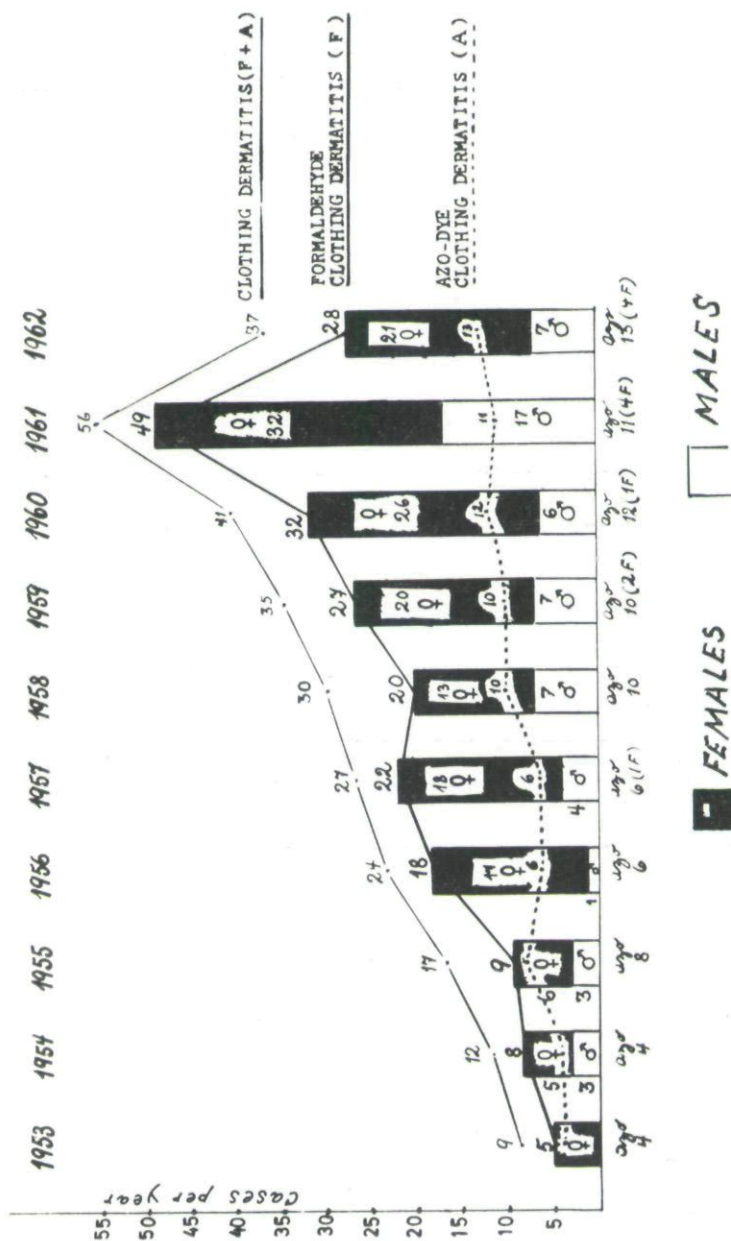


Fig. 4.

Allergic contact dermatitis from clothing. In-patients only. The columns are representing cases due to formaldehyde sensitivity (F) (black for females, white for males). The dotted line represents cases of azo-dye dermatitis (both sexes).

TABLE 1
*Formaldehyde Clothing Dermatitis (In-patients).
 10 Year Period, annual Incidence.*

Year	Allergic contact cases	Formaldehyde clothing cases	In per cent
1953	257	5	1.9
1954	246	8	3.3
1955	208	9	4.3
1956	217	18	8.3
1957	217	22	10.2
1958	246	20	8.1
1959	251	27	10.8
1960	231	32	13.9
1961*	212	49	23.1*
1962	168	28	16.7
Total	2253	218	9.7

TABLE 2
In-patients Series. Results from Patch Testing with Formaldehyde (4 per cent aqueous Solution). Positive Reactors in per cent of Patients Tested are Compared with the Annual Number of Formaldehyde Clothing Dermatitis.

Year	Number of patients patch tested		Total	Positive reactors to formaldehyde		Formaldehyde clothing dermatitis	
	Males	Females		Males in %	Females in %	Males	Females
1953	243	285	501	22 (9.1)	45 (17.5)	0	5
1954	242	197	439	48 (19.8)	30 (15.1)	3	5
1955	146	140	286	29 (20.1)	30 (21.3)	3	6
1956	205	184	389	38 (18.5)	45 (24.5)	1	17
1957	212	185	397	37 (17.5)	36 (19.5)	4	18
1958	255	211	466	44 (17.3)	38 (19.2)	7	13
1959	262	244	506	36 (13.7)	52 (21.3)	7	20
1960	255	260	515	42 (16.6)	65 (25.0)	6	26
1961	279	306	585	50 (17.9)	67 (21.9)	17	32
1962	237	240	585	40 (16.9)	52 (21.2)	7	21
Total	2336	2225	4561	386 (17.0)	460 (20.7)	55	163

DISCUSSION

The present study is mainly a retrospective one, and conclusions drawn merely from the statistical data must be guarded, because of the great number of variables having influence on the results. However, the figures and tables clearly show that in the present in-patient material there has been a relatively steady increase in the incidence of formaldehyde clothing dermatitis since 1953 up to the maximum year 1961. This is in good accord with the statement of *Marcussen* (10) that it has increased remarkably in Denmark since the year 1952. As from this year clothing treated with formaldehyde resins was introduced more generally on the market in Scandinavia. Women's clothing was the first to be affected. Resin treated cotton shirts for men did not come into general use in Norway until 1956-57, and this was followed by a certain rise in the male cases of dermatitis. Out of the first 6 males recorded in Fig. 4 (1954-55) 3 were young men in the military forces having contracted their dermatitis from dermaldehyde used to treat some army textiles at that time. This procedure appears to have been discarded because of dermatitis among soldiers.

The drop in annual incidence from 1961 to 1962 (Fig. 4) may have three different causes. 1) Formaldehyde clothing dermatitis is now better known to practising doctors, who are capable of treating the patients without referring them to a hospital. 2) There may be a real fall in incidence because if most of the individuals predisposed to this kind of dermatitis have had it and are under observation and prevention, new cases will gradually become rarer. 3) The textile manufacturers may have taken into consideration the increased publicity of this almost epidemic rise in clothing dermatitis, and therefore have started to discard the use of formaldehyde resins and introduced alternative methods.

Another fact suggesting that the problem of formaldehyde clothing dermatitis may be but a temporary one, is that cloth containing formaldehyde amine resins sometimes deteriorates

and discolours when being washed in a detergent containing a hypochlorite bleach. This is one of the reasons why textile manufacturers are already investigating chemical substitutes for these resins (4).

The overall rise in the diagnoses of clothing dermatitis caused by formaldehyde might be partly due to physicians displaying an increased awareness of the problem. The formaldehyde cases therefore have been compared with the incidence of azo-dye cases. The routine patch-testing in this Hospital has been substantially unchanged during the period of observation, with the exception that the 3 "aniline derivatives" (aminoazotoluol, p-phenylenediamine and p-aminophenol) did not become a completely obligatory part of the standard battery of patch tests until 1957-58. This fact may account for the lower incidence of azo-dye cases diagnosed during 1953-57 (Fig. 4). Since 1958 the annual number of azo-dye cases have been at a remarkably constant level (approx. 10 cases per year). This gives support to the view that the rise in formaldehyde clothing dermatitis is a real one. 4 per cent solution of formaldehyde has always been included in the standard series of patch tests, which is applied to almost all eczematous patients. All of the 218 formaldehyde clothing patients gave a positive (eczematous) formaldehyde reaction.

Another feature which might be noted, is that during the last part of the period some patients (up to 4 per year) with clothing dermatitis have been allergic to both azo- or aniline-dye and formaldehyde. This appears to be in keeping with the view that skin rendered eczematous by one of these clothing allergens is more easily sensitized also to the other, than is normal skin.

The question still arises why some individuals with contact allergy to formaldehyde contract dermatitis from resin-treated textiles, while other formaldehyde sensitive patients do not. The age and sex distribution (Fig. 3) seems to show a maximum of cases in the female climacteric group. In this age period many women experience an increased sweat secretion, especially from the axillary glands. The male cases are more

evenly distributed among all the age groups. The azo-dye cases (white columns in Fig. 3) show an increased incidence with higher age, apparent in both sexes. This incidence with age would probably have been still more impressive if the diagram had been correlated with the normal mortality in the population.

It seems evident that some formaldehyde sensitive persons are especially prone to depolymerize formaldehyde resins on their skin and contract dermatitis from resin-treated textiles during certain periods of their life, while in other periods they tolerate wearing such garments in spite of still being positive to formaldehyde patch tests.

The present author believes that nervous stress and psychic conflicts, among other factors, are capable of causing differences in sweat secretion, quantitatively and may be qualitatively, and can by this means act as cause of increased resin depolymerization leading to formaldehyde clothing dermatitis.

The reason why the present material (Table 2) shows a much higher incidence of formaldehyde reactors than Hövding's series from Bergen (7) and Marcussen's from Copenhagen (10), may be that the present study is dealing with a selected group of in-patients, while the series of other investigators have comprised out-patients as well. Because of the long distances from this Hospital to the homes of many patients, some of them may have been patch-tested rather early in the course of their dermatitis, and retesting after discharge from the hospital is in most cases impracticable. This may account for some false positive reactions. However, this factor has been unchanged all the time, and there is no reason to believe that the frequency of false positives should have increased during the period of observation.

It is most interesting to notice that this dermatological entity of formaldehyde clothing dermatitis so well established in Scandinavia, still appears not to be accepted at all by some American investigators (5). This could hardly be explained merely by a more effective washing of the fabrics performed by the American textile manufacturers, in order to remove

remnants of free formaldehyde. The question arises whether there might exist a difference in the liability of human skin to depolymerize formaldehyde resins, dependant on racial, nutritional and climatic factors?

From the climatic point of view it seems still more surprising that this cause of contact eczema is not more frequently encountered in the many subtropical areas of the U.S.A. where sweat-moistened clothing on hot skin is probably a far commoner occurrence than it is in Norway.

SUMMARY AND CONCLUSIONS

During the ten year period 1953-1962, a total of 12,955 in-patients were treated in the Department of Dermatology, Rikshospitalet, Oslo, and 2,253 of them were diagnosed as *Eczema idiosyncraticum* (Allergic contact dermatitis). 218 (9.7 per cent) of these cases of allergic contact dermatitis were believed to have contracted their dermatitis through allergy to formaldehyde in clothing. The incidence of formaldehyde clothing dermatitis in this series has shown a remarkable increase from 1.9 per cent of the annual number of allergic contact dermatitis cases in 1953 to a maximum of 23.1 per cent in 1961.

Of the 218 patients, 163 were females and 55 males, the ratio for females to males being approximately 3 to 1.

The incidence of formaldehyde clothing dermatitis is compared with that of clothing dermatitis from allergy to dyes during the same period.

It is concluded that formaldehyde amine resins, particularly formaldehyde melamine and formaldehyde urea, may gradually depolymerize while in contact with human skin. Free formaldehyde thus released is capable of causing allergic contact dermatitis. This depolymerization seems to be facilitated by sweat and the higher temperature of the flexures.

The climacteric, psychic conflicts and other nervous factors are thought to have some influence on the liability of human skin to break down formaldehyde resins in clothing. This may

explain why some individuals, who are allergic to formaldehyde, contract this type of clothing dermatitis while other formaldehyde sensitive patients do not. Unknown constitutional factors, racial, nutritional, and climatic circumstances may also be of importance, and might explain why this "Scandinavian epidemic" of formaldehyde clothing dermatitis is not encountered in some other countries?

In the present study, Schiff's reagent for detection of aldehydes is found useful in testing patients' garments in order to exclude from their wardrobe textiles capable of releasing formaldehyde.

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