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PATCH TESTING WITH MINERAL WOOL (ROCKWOOL®)

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Abstract. 25% of 315 tested subjects exhibited skin reactions when patch tested with mineral wool. Coating of the mineral fibres with phenol-formaldehyde did not influence the skin reactions. The reactions seem to be induced mechanically, as the mineral without the fibres did not give any reactions. No allergic reactions to the chemical additives were demonstrated. Macroscopically, the reactions may simulate an allergic response; microscopically, they seem to be toxic, sometimes with prominent spongiosis.

Key words: Mineral wool; Fibres; Patch testing; Irritant dermatitis; Toxic reaction

Mineral wool (mineral cotton, silicate cotton, rockwool, slag wool) is a versatile product with an ever increasing use as an insulating material in the building industry. It is well known that it may cause severe itching and skin reactions on direct contact with the skin. Many workers seem to become hardened and the itching abates despite constant contact with the material. These skin reactions are mostly looked upon as a primary irritant contact dermatitis induced mechanically by the fibres (3, 5). Allergic contact dermatitis to substances in the finishers of the fibres has also been described (1). In this investigation patch test reactions to a mineral wool were studied to ascertain whether they were allergic, caused by additives, or non-allergic, caused by the physical properties of the fibres.

Rockwool® (Skövde, Sweden) is manufactured by melting the mineral basalt together with limestone and coke. The melt is transformed into thin fibres of 4–10 μ diameter. The length of the fibres in the product is about 3 mm. Some 10% of the mass forms small mineral pearls instead of fibres. The fibres are collected as a wool. Phenol-urea-formaldehyde is added to the wool as a binder. Barium hydroxide is used as a catalyst and a resole is formed. The coating resin is completely cured by heat, forming a resite. The binder is diluted with ammonium and a silicone compound (gamma-amino-propyl-triethoxy-silane). A mineral oil (Nynäs CM-14) is added as a dust binder.

The chemical composition of the Rockwool fibres is: SiO_2 45%, Al_2O_3 14%, CaO 20%, MgO 9%, Fe 6%, MnO 0,5%, K_2O 0,5%, Na_2O 1%. It is chemically inert.

MATERIAL AND METHODS

A. *Test substances*

1. Rockwool as commercially available.
2. Rockwool with the same fibres as in 1 but without chemical additives (uncoated)
3. Rockwool without fibres and without chemical additives, supplied as a powder
4. Chemical additives: Phenolformaldehyde resin 5% pet., silicone (gamma-amino-propyl-trietoxysilane) 50% aq., mineral oil 50% o.o. and the ready-made binder 5% alc., containing free phenol and formaldehyde, barium hydroxide, the silicone compound and ammonium.
5. A standad series of allergens: Potassium dichromate 0.5%, paraphenylenediamine 2%, thiurammix 1%, neomycin sulphate 20%, cobalt chloride 1%, benzocaine 5%, nickel sulphate 2.5%, Vioform 5%, colophony 20%, parabens 15%, wood tars 12%, PPD-mix 0.6%, wool alcohols 30%, mercaptomix 1%, coal tar 5%, Sterosan 5%, Peru balsam 25%, naphthylmix 1%, formaldehyde 2%, diaminodiphenylmethane 0.5%, ethylene diamine 1%, chlorocresol 1%.

B. *Test methods*

All individuals were tested on normal skin on the upper back. The aluminium patch test according to Fregert was used in all tests, with both fibres and with the allergens, with an exposure time of 48 hours and reading of the results after 72 hours. Roughly the same amount of fibres was used in all tests, covering the inner surface of the patch test unit. In order to estimate the error of the methods used in the fibre tests, patches were applied symmetrically in duplicate on the right and left sides.

Registration of skin reactions. When reading the results of the fibre tests, the following scale was used: 0= normal skin, +=slight erythema or a few solitary pale papules, ++=erythema, papules, slight infiltration,

Table I. *Patch testing with coated and uncoated Rockwool and Rockwool as a powder in 20 patients previously positive to Rockwool.*

	No. of positive reactions
Rockwool as commercially available (coated)	16/20
Uncoated Rockwool	14/20
Rockwool as a powder	0/20

+++=erythema, infiltration, papules, vesicles and/or erosions. In evaluating the error of the method these reactions were assessed as follows: +=2, ++=4 and +++=6. Intermediate reactions were designated 1, 3 and 5. The test reaction to allergens was designated as positive or negative.

C. *Microscopic examination*

In 12 patients punch biopsies were taken from the centre of the fibre test reaction at 72 hours. They were fixed in formalin and stained with hematoxylin-eosin and van Gieson.

D. *Statistical methods*

In the statistical evaluations the χ^2-test was used. The error of the method was calculated according to Dahlberg, 1948. Values of $p<0.05$ were considered significant.

E. *Series of patients tested*

(*a*) 315 patients (124 men, 191 women) aged 15–87 years referred for routine patch testing participated in the tests on Rockwool as commercially available and on the standard series of allergens. None had active eczema at the time of testing.

(*b*) 20 patients who initially showed strong positive reactions (++, +++) to Rockwool were retested with Rockwool, uncoated Rockwool and uncoated Rockwool in powderform.

(*c*). The same 20 patients as in (*b*) were tested with the chemical additives.

(*d*) In order to estimate the error of the test method, 78 patients were tested in duplicate with coated and uncoated Rockwool.

RESULTS

1. *Patch testing*

(*a*) *Reactions to Rockwool as commercially available.* Of the 315 patients 32 (10%) reacted with a + reaction and 47 (15%) with a ++ or +++ reaction to Rockwool. Macroscopically, a papular-vesicular reaction in some cases simulated a true allergic patch test reaction. In other subjects the picture was dominated by superficial small erosions. Some weak reactions showed a few skin-coloured, often follicular, papules without erythema, while in others there was only a slight erythema without papules. Most patients reported itching from strongly positive test reactions.

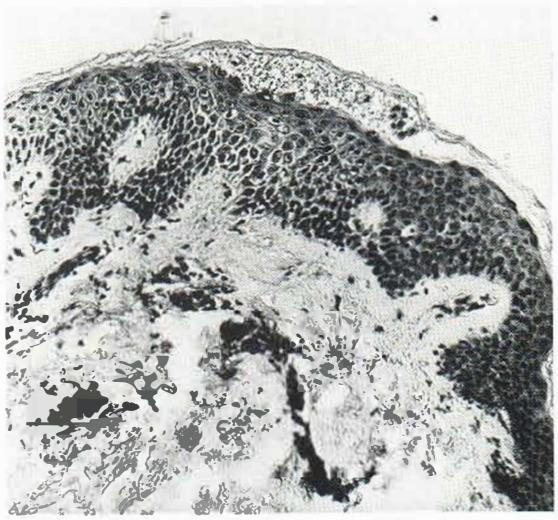

Fig. 1. Biopsy of a patch test reaction to Rockwool at 72 hours, with subcorneal vesicle.

The age distribution of positive reactors did not show statistically significant predominance in any decade. No statistically significant differences were found between men and women with respect to the occurrence of the test reactions.

(*b*) *Reactions to standard series of allergens.* The Rockwool-positive (+ to +++) and the Rockwool-negative individuals were compared with regard to their reactions to the standard series of allergens. Of the 79 people positive to Rockwool, 43% reacted with one or more allergic reactions, and of the 236 subjects negative to Rockwool, 42% exhibited allergic reactions. The difference is not statistically significant. The numbers of reactions to the indi-

Table II. *Patch testing with additives to Rockwool in 20 patients strongly positive to Rockwool*

Substance	No. of positive reactions
Binder 5% alc.	1/20
Hardened resin	0/20
Mineral oil 50% o.c.	0/20
Silicone 50% aq.	0/20
Paratertiary butylphenol 1% pet.	1/20
Phenol-formaldehyde 5% pet.	0/20
Formaldehyde 2% aq.	1/20

Fig. 2. Biopsy of a patch test reaction to Rockwool at 72 hours, with spongiosis and a dense inflammatory infiltrate of lymphocytes and leukocytes.

vidual allergens were similar in those positive and negative to the fibre tests, with one exception, Peru balsam, to which the Rockwool-positive individuals reacted more frequently than those who were negative, 12/79 versus 16/236. The difference is statistically significant.

(*c*) *Reactions to fibres* (Table I). Of the 20 previous Rockwool-positive patients retested with different types of fibres, 16 reacted (+ to +++) positively to coated Rockwool and 14 to the uncoated product. The difference is not statistically significant. This is also relevant when the reactions are divided into + and ++ to +++ reactions. None reacted to Rockwool as a powder without the additives and fibres.

(d) Reactions to allergens related to the manufacturing of Rockwool (Table II). A few allergic patch test reactions occurred in 20 patients strongly positive to Rockwool in the further tests with the chemical additives used in the coating process. The exceptional positive reaction to the binder in one patient could not be explained.

(*e*) *Error of the method in patch tests with Rockwool.* In patch tests with coated Rockwool the error of the method was 24% and with uncoated Rockwool it was 26%, expressed as a percentage of a maximum score, 6.

II. *Microscopic examination*

Microscopically, three main features were seen: subcorneal vesicles or bullae, containing polymorphous leukocytes (Fig. 1), sometimes developing into a superficial erosion; spongiosis with a mononuclear or polynuclear cell infiltration in the epidermis (Fig. 2), and perivascular lymphocytic infiltration in the dermis (Fig. 3). These three types were usually seen simultaneously but in some cases the dermal reaction dominated the picture with absence of epidermal changes. This corresponded macroscopically to a slight erythematous dermal infiltration without papules or vesicles.

DISCUSSION

About 25% of 315 tested subjects reacted positively when patch tested with coated mineral wool. Roughly the same figures were obtained when patch tested with fibreglass (2).

Fig. 3. Biopsy of a patch test reaction to Rockwool at 72 hours, with dermal, mainly perivascular, infiltrate of lymphocytes.

In the present series no predisposition to the test reactions could be demonstrated for any sex or age group. The error of the patch tests with the Rockwool, coated as well as uncoated, was as high as 25%, when the same subjects were tested symmetrically on the left and right side of the back. Provocation of the skin reactions seems to be greatly influenced by various factors, such as external pressure on the tests unit. The skin reactions in the patch tests with Rockwool seem to be mechanically induced, as only the fibrous products of the mineral gave rise to reactions, and not the powder product. A similar finding has also been demonstrated recently in the case of glassfibres (2).

It has previously been shown that the diameter of glass fibres (5) and mineral wool fibres (3) is of importance in the skin reactions. Workers in contact with fibres were shown to have an increased number of positive patch test reactions to the fibres as compared with controls (4).

The coating with phenol-formaldehyde in the present series had no effect on the skin reactions. Nor did a starch-base (5) or a cured epoxy resin (2) affect the reactions, when used to coat the glass fibres.

In some cases, the patch test reactions with Rockwool, have an "allergic" macroscopical appearance, while in others an erythematous dermal infiltration dominates the pictures. Microscopically, superficial bullae, spongiosis and dermal infiltration occur in varying proportions, with the spongiotic proportion dominating in some cases and the dermal infiltration in others. The findings correspond to those observed with glass fibres (2). No allergic reactions to the chemical additives used in the Rockwool manufacturing process were observed in the Rockwool-positive subjects. In the tests with the series of standard allergens the number of allergic reactors among the fibre-positive subjects was not greater than among the fibre-negative subjects. There was no correlation between the skin reactivity to the fibres and any allergen in standard patch tests, with one exception: the fibre-positive subjects reacted more often to Peru balsam than did the fibre-negative individuals. This finding is interesting as it has been demonstrated (4), that workers in a mineral wool factory who reacted to patch tests with the fibres also reacted more frequently to pine oil than did the fibre-non-reactive workers. The increased reactivity to aromatic substances in the fibre reactors cannot be explained.

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