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Allergic contact dermatitis caused by benzanthrone in a pair of trousers

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Dermatitis caused by clothing can have different aetiologies. It can be an urticarial reaction (1), a reaction caused by irritation (2, 3), or an allergic contact reaction. This reaction can be caused by the textile fibres (1, 4) themselves, even though this is uncommon, but most often caused by textile dyes (4) or other chemical components added to the textile to give the material a certain quality or finish (5, 6). Contact allergy to textile dyes is usually described for synthetic clothing and the dyes used for these, among which are disperse dyes, anthraquinone-based dyes, and azo dyes. Here, we describe a case of contact allergy to benzanthrone, an intermediate in the production of vat dyes, which are mainly used for dyeing cotton fabrics.

Background

Azo and anthraquinone dyes are currently the two most important classes used for dyeing textile fibres. Azo dyes are characterized by the presence of at least one azo group ($-N=N-$) in the chromophore, and anthraquinone dyes have two carbonyl groups ($>C=O$) in the chromophore (4). Benzanthrone (CAS no. 82-05-03) is an intermediate substance used in the production of vat dyes (7). These are often used in the colouring process for cellulose fibres such as cotton (7). Benzanthrone is already known to be irritating to the skin (8) and to cause phototoxic and, perhaps, photoallergic reactions (9).

Case Report

A 39-year-old woman employed in selling jewellery was referred to the Department of Occupational and

Environmental Dermatology after having experienced a rash on her lower abdomen that she ascribed to the use of a newly purchased pair of trousers. Very soon after buying them, she developed a rash on her abdomen in the region of the trouser lining. On re-exposure, her itchy rash re-occurred. Examination showed no dermatitis. She had suffered from asthma as a child, but no other atopic manifestations and no skin lesions. During pregnancy, she had experienced pruritic and urticarial papules and plaques of pregnancy. In her family, there were no atopic manifestations or skin diseases.

Patch Testing

The patient was patch tested with the baseline series used in the department and the textile dye series, with Finn Chambers® (Ø 8 mm; Smart Practice, Phoenix, AZ, USA) on Scanpor® tape (Norgeplaster A/S, Venne, Norway). Twenty milligrams of test preparation was added to each Finn Chamber® and 15 µl of liquid preparation (10). The patch tests were removed after D2.

Readings were performed according to the International Contact Dermatitis Research Group criteria, with two classifications added to differentiate between strong and weak +, ++ and +++ reactions (11, 12), on D3 and D7. The patient was also asked to put on her trousers to provoke a dermatitis. She was found to be positive to gold sodium thiosulphate, but had no history of clinical manifestations of dermatitis when in contact with gold. No other positive reactions were found. When she attended for the first patch test reading, a dermatitis had been provoked (Fig. 1) on her lower abdomen that looked almost urticarial. A punch biopsy was taken, and showed an eczematous reaction.

The patient's trousers were then examined (Fig. 2). Two extracts, in water and acetone, were prepared from material from the upper part of the trousers,

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Fig. 1. The dermatitis provoked by wearing the trousers for 2 days.



Fig. 2. The inner lining of the trousers.

corresponding to the region where the patient's dermatitis was situated (13).

The patient was tested with the extracts at 100%, 10%, and 1%, and had strong positive reactions to the acetone extracts at all concentrations. Also, these reactions looked slightly urticarial, and a punch biopsy was performed. The biopsy showed acanthosis, papillomatosis, perivascular infiltration, and intraepidermal vesicles and spongiosis.

Twenty-three controls were tested with the 10% extract, and showed no reactions ($p = 0.042$; Fisher's exact test, two-sided).

Thin-layer chromatography (TLC) was performed in order to separate the components of the extract of the textile and to obtain a TLC strip for patch testing (TLC plastic roll, Silica Gel 60F 254, Merck KGaA, Darmstadt, Germany) (14). When patch tested, the patient showed one positive reaction (Fig. 3). The spot of the TLC strip that corresponded to the positive reaction was scraped off and extracted. The solution was analysed by gas chromatography–mass spectrometry (GCMS). Separation of components in the solution was performed with an Agilent 6890N gas chromatograph (Agilent

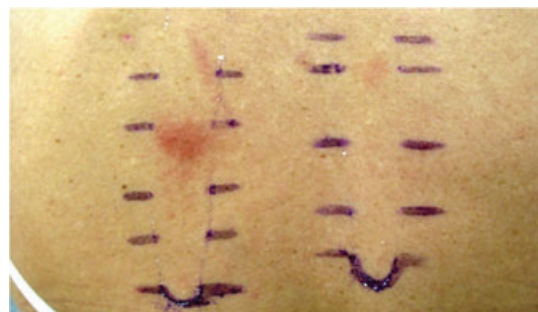


Fig. 3. The positive test reaction to the thin layer chromatogram (performed with 16 μ l of 100% acetone extract from the jeans textile).

Technologies, Palo Alto, CA, USA) equipped with an HP-MSI capillary column (Agilent Technologies) with a length of 30 m. The gas chromatograph was connected to a Jeol GCmate II mass spectrometer (Jeol Datum, Tokyo, Japan). Electron-ionization (70 eV) mass spectra were recorded with m/z from 50 to 600. The National Institute of Standards and Technology (Gaithersburg, MD, USA) library of mass spectra was used for identification of substances. It was found that the positive TLC spot contained three substances: octyl-4-methoxycinnamate, ethylhexyl-*trans*-4-methoxycinnamate, and benzanthrone.

The patient was then patch tested with these substances at two concentrations: octyl-4-methoxycinnamate (Acros Organics, Geel, Belgium) at 2.0% wt/wt and 0.20% pet.; ethylhexyl-*trans*-4-methoxycinnamate (Acros Organics) at 2.0% wt/wt and 0.20% pet.; and benzanthrone (> 98%; TCI Europe, Zwijndrecht, Belgium) at 1.0 (300 μ g/cm²) and 0.10% wt/vol (30 μ g/cm²) in ethanol/acetone 50:50 vol/vol (15). She was found to be positive for both concentrations of benzanthrone, with a + reaction for the higher concentration and a + reaction for the lower concentration (Fig. 4). A dilution series with benzanthrone was tested on the patient, but showed no positive reactions at concentrations lower than 0.1%. Because it has been stated in the literature that the substance might actually cause phototoxic or, possibly, photoallergic reactions, the patient was photopatch tested with the substance at two concentrations (1.0% wt/vol and 0.32% in ethanol/acetone 50:50 vol/vol). In photopatch tests with an occlusion time of 24 hr, no reaction was seen after exposure to ultraviolet (UV) light.

Different parts of the jeans were extracted and analysed with GCMS for benzanthrone. The main jeans fabric contained no detectable benzanthrone (< 1 ng/cm²). The majority was found in the black inner fabric of the lining,



Fig. 4. The positive reactions to benzanthrone, 1.0% and 0.10% wt/vol.

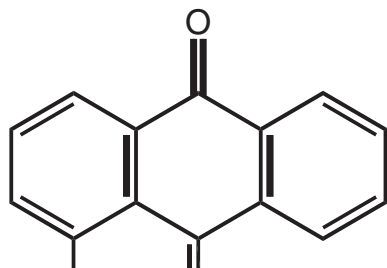


Fig. 5. Chemical structure of benzanthrone.

in total 5 mg, corresponding to a benzanthrone lining concentration of $14 \mu\text{g}/\text{cm}^2$.

Conclusions

The patient had developed a dermatitis when using a new pair of trousers. After investigations including patch testing with extracts and TLC, photopatch testing

and chemical analyses with GCMS, the dermatitis was diagnosed as allergic contact dermatitis caused by benzanthrone in a pair of jeans. Benzanthrone (CAS no. 82-05-3) (Fig. 5) is used in the pyrotechnics industry and to produce some important vat textile dyes, for example Vat Blue 20 and Vat Green 1. Benzanthrone is light yellow to brown in appearance, insoluble in water, and soluble in alcohol and acetone. It has luminescent properties, and shows brilliant fluorescence. Benzanthrone has been reported to cause systemic symptoms from the gastrointestinal tract, liver malfunction, and skin lesions (15–17). Regarding skin lesions, benzanthrone has been reported to cause dermal toxicity (18), phototoxicity, and, possibly, photoallergic reactions (8, 19, 20). There is very little evidence in the literature for benzanthrone being a contact allergen. The substance was found in the inner lining of the trousers at a concentration that corresponded well to the patient's reactivity when she was patch tested with benzanthrone in the dilution series. The skin where the dermatitis occurred was not exposed to UV irradiation, and a negative photopatch test result was obtained when she was tested with benzanthrone. Theoretically, an irritant reaction could, of course, also be the explanation, giving, in this case, a false-positive reaction. However, the patient actually showed positive reactions that were morphologically consistent with an allergic nature, to the recommended dose for testing benzanthrone and also to one-tenth of that concentration. Furthermore, the histology supported an eczematous reaction, and the negative test results in controls strongly favoured the interpretation that the positive test reactions to benzanthrone in our patient represented contact allergic reactions.

Thus, in conclusion, there is strong evidence that the patient suffered from allergic contact dermatitis caused by benzanthrone in jeans. Patch testing with benzanthrone should be considered whenever a cotton-based textile is suspected to be the cause of dermatitis.

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