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Contact Dermatitis (A Giménez-Arnau, Section Editor)

Textile Contact Dermatitis: How Fabrics Can Induce Dermatitis

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Abstract

Purpose of the review Textile dermatitis can sometimes be difficult to diagnose due to the fact that it is difficult to clinically suspect, and when allergic, patch test correctly and advice the patient as to what garments to avoid.
Recent findings The textile fibres as such are rarely the causative agent. Allergic contact dermatitis due to textiles is primarily caused by substances that are used to give the material certain qualities or performances. The textile dye mix, now in the baseline series, has proven to be a useful tool in diagnosing allergic contact dermatitis but additional patch testing with own material is advocated. Future research will hopefully facilitate the diagnostic procedure.
Summary This review is a short update on textile dermatitis, both irritant and allergic, the present recommendations regarding patch testing when suspecting contact allergy and the advice to give to those allergic that will hopefully help the clinician in daily work.

Introduction

Contact dermatitis from textiles typically gives different clinical pictures, depending on whether the dermatitis is caused in the worker during the production of the textiles or in the consumer. Other important factors are the quality of garment, how it is worn and, when due to contact allergy, what the causative hapten is. Within the

textile industry, the production process as such, in which the use of various types of chemicals seems to be ubiquitous, makes the industry a growing possible problem regarding public health as well as in the environment. From dyehouses, the wastewater discharge has serious detrimental effects on the aquatic environment. Some dyestuffs produce toxic decomposition products and the metal complex dyes release toxic heavy metals to the water. Of the dyes used in the textile industry, effluents containing reactive dyes, where considerable amounts are lost and discharged during production, are the most difficult to address [1, 2]. When investigating possible contact allergy as causative agent, it should be remembered that some of the substances used during the production can actually be found also in the finished garments such as quinolone compounds [3–6]. In studies where occupational dermatoses have been investigated within the dye industry and textile industry, associations have been found with azo dyes in textile workers, and formaldehyde and chromate in those working in the leather and dyeing industries [7, 8]. In the latter study, occupational allergic contact dermatitis was found associated with lesions that were primarily on the hands and wrists of the workers. Also, those selling textiles risk hand dermatitis and even widespread occupational allergic contact dermatitis has been reported amongst this group [9].

Contact dermatitis in those using the garment is often diagnosed when appearing as a chronic dermatitis, i.e., there is often a delay in diagnosis. It may be found in areas preferably with close contact between skin and textile (especially where friction or perspiration occurs), but may also be widespread [10, 11•, 12]. However, textile "dermatitis" can also be found with no clinical morphology but symptomatic pruritus. Nummular dermatitis, and even a clinical picture of atopic dermatitis, involving flexures, is not infrequent [11•, 13]. The morphology of the dermatitis may differ from erythema-like or urticaria-like lesions to pigmented purpura [13].

Textile contact dermatitis

Textiles are made of fibres: natural wool, linen, cotton and silk and synthetic cellulose derivatives and polyamides. Other materials such as metal or rubber components may be added to give the textile a certain wanted characteristic, and for the same reason, the textile is further processed; textiles are coloured or prepared with different substances in order to produce specific effects or give the garment a certain quality [10]. Can the fibres per se give rise to textile dermatitis? With regard to allergic reactions to wool, both type I and type IV reactions have been reported, but these publications are usually of older date. In a recent review, Zallmann et al. [12•] found that to date, there is an absence of evidence to substantiate allergy (type I and IV hypersensitivity) to wool fibres. Furthermore, allergens associated with wool processing (e.g. chemical dyes) are present at negligible levels within modern wool garments. Cutaneous irritation caused by wool garments was previously often found and most probably due to high fibre diameters. Superfine and ultrafine Merino wool garments with finer fibre diameters seem to be much better tolerated [12•].

The same is true for cotton, where the occurrence of an immediate skin reaction to textiles is extremely rare [13]. Cotton clothing occasionally causes itchy skin or erythema, but this is usually due to skin irritation [13]. As to silk, this material has even been tried to alleviate dermatitis symptoms [14]; however, there also exist occasional case reports on immunological contact urticaria from silk exposure [15].

Textile contact dermatitis is however not uncommon [11•] and of major concern are contact allergic reactions. The major causes for allergic reactions in textiles are thus caused by how the textile is prepared and treated [12•, 16, 17],

where biocides [18] have also been the cause of dermatitis. In the textile, these are used for protection during manufacture or transport and to inhibit malodour, especially, for example, in textiles used in sports. Various biocides in textiles have been reported, including triclosan, zinc pyrithione, MCI/MI, dichlorooctylisothiazolinone, dimethyl fumarate, and silver particles [19–21]. Other substances remaining after dyeing (e.g. benzanthrone, an intermediate substance used in the production of vat dyes) or treating textiles (e.g. sulfites, used during bleaching) can induce allergic contact dermatitis [22, 23]. With regard to allergic contact dermatitis to formaldehyde, urea-formaldehyde resin and melamine-formaldehyde resin, used in the textile industry since the 1920s to prevent wrinkling, have been found to be causative agents. Formaldehyde release has been documented for many fibre types [24–26], and in some countries, regulative measurements have been taken. Formaldehyde content varies in studies from different countries; wool is however suggested as a secure textile material for those sensitized [12•, 26–29].

With regard to textile dyes as causes of allergic reaction, type I reactions exist [30, 31] but are very rare, whereas type IV reactions are the most frequent, and therefore the focus in this review.

Table 1. Usage classification of dyes according to K. Hunger [33] with modifications by the authors

Dye class according to application	Main substrates	Dye classes according to chemical structure	Described as allergens
Acid	Nylon, wool, silk (also paper, inks, leather)	Azo, anthraquinone, triphenylmethane, azine, xanthenes, nitro, nitroso	Rare
Azoic	Cotton, rayon, cellulose acetate, PET	Azo	
Basic	Polyacrylonitrile, modified nylon, PET (also paper, inks)	Cyanine, hemicyanine, diazahemicyanine, diphenylmethane, triarylmethane, azo, azine, xanthene, acridine, oxazine, anthraquinone	Rare (Basic Red 46—important allergen in acrylic socks)
Direct	Cotton, rayon, nylon (also paper, leather)	Azo, phthalocyanine, stilbene, oxazine	Rare (some cases of immediate type allergic reaction)
Disperse	PET, polyamide, acetate, acrylic (also plastics)	Azo, anthraquinone, styryl, nitro, benzodifuranone	Most frequently
Mordant	Wool (also leather)	Azo and anthraquinone	
Reactive	Cotton, wool, silk, nylon	Azo, anthraquinone, phthalocyanine, formazan, oxazine, basic	Described only as occupational allergens
Solvent	Plastics, fuels, varnishes, lacquers, inks, oils, waxes	Azo, triphenylmethane, anthraquinone, phthalocyanine	Rare
Sulphur	Cotton, rayon	Indeterminate structures	Exceptionally rare
Vat	Cotton, rayon, wool	Anthraquinone, indigoids	Rare

In order to identify a possible culprit, colour identification of the agent is necessary; however, the classification of dyes is complicated since they can be classified either according to chemical structure or according to method of application. Classification according to the colour (the Colour Index, C.I.) is compiled and edited by the Society of Dyers and Colourists and by the American Association of Textile Chemists and Colorists. In the lists, there are thousands of dyes, but since every generic name covers all colourants with the same structure, they are not necessarily identical with regard to possible additives or impurities. This has also been a problem with regard to patch testing where test substances, thought to be defined, have been found to contain impurities [32].

The dye used depends on the fabric. Different colours are used for synthetic and for natural fibres (Table 1). The overall rate of sensitization to reactive dyes, used to colour natural fibres including cotton, silk and wool, is very low. In a publication by Manzini et al. [34], it was reported that 18 of 1813 patients (0.99%) tested with the additional textile series had positive reactions to reactive dyes over 1 year. Disperse dyes (DD) are used for colouring synthetic textiles, polyester, nylon and fibre mixtures [11•] and account for > 20% of the dyes produced in the world [35]. They only partially bind to textile fibres which may explain their sensitization properties. The small, lipophilic molecules can easily migrate onto the skin especially if the textile fastness is poor [33]. Approximately 60% of all DDs are azo dyes and about 25% are anthraquinone dyes, with the remainder being quinophthalone, methine, naphthalimide, naphthoquinone and nitro dyes [35]. Azo dyes are cheap and easy to apply and can give all range of colours, making it the most common group [35]. Within the EU and by the International Oeko-Tex Association (a group of textile research and test institutes), some DDs (mainly azo dyes) are classified as allergenic, and their use is restricted [36, 37]. Contact allergy to DD dyes has long been known and different clothing have been in focus, such as, when in the 1940s–1950s, cases of reactions to nylon stockings were reported [38]. Already then, the risk of missing the allergy due to the fact that the dermatitis might mimic, for example, foot dermatitis, was raised. The allergic contact dermatitis seen in relation to DDs varies, ranging from non-pruritic erythema, especially seen with Disperse Blue 106 and 124, persistent erythematous-wheal-like or transient urticarial dermatitis, to erythema multiforme-like lesions [39–41]. Also, lymphomatoid dermatitis [42] and folliculitis [43] have been described. Hand dermatitis is not uncommon. Involvement of skin folds was observed in 27% of DD-positive patients, mainly comprising those sensitized to Disperse Blue 106 and 124 [44, 45]. It may thus mimic or worsen an atopic dermatitis [46]. Today, when systemic therapy is increasing in use and new drugs are introduced for patients with widespread atopic dermatitis, the need to exclude the possibility of a causative or aggravating agent in a contact allergy is increasingly important. Also, since dupilumab seems to possibly suppress the reactivity in contact allergic [47•], DDs were not initially included in any baseline series, in contrast to p-phenylenediamine (PPD), which, historically, has been considered to be a screening allergen for textile dye dermatitis. However, later reports indicate that PPD does not represent a suitable marker allergen for detecting sensitization to all azo dyes present in textiles [35]. The prevalence of DD contact allergy varies with the population and the dyes tested. In those studies [11•] in which patients were routinely patch tested and DDs were included (in total, 26 DDs were used for patch testing in 1% pet.

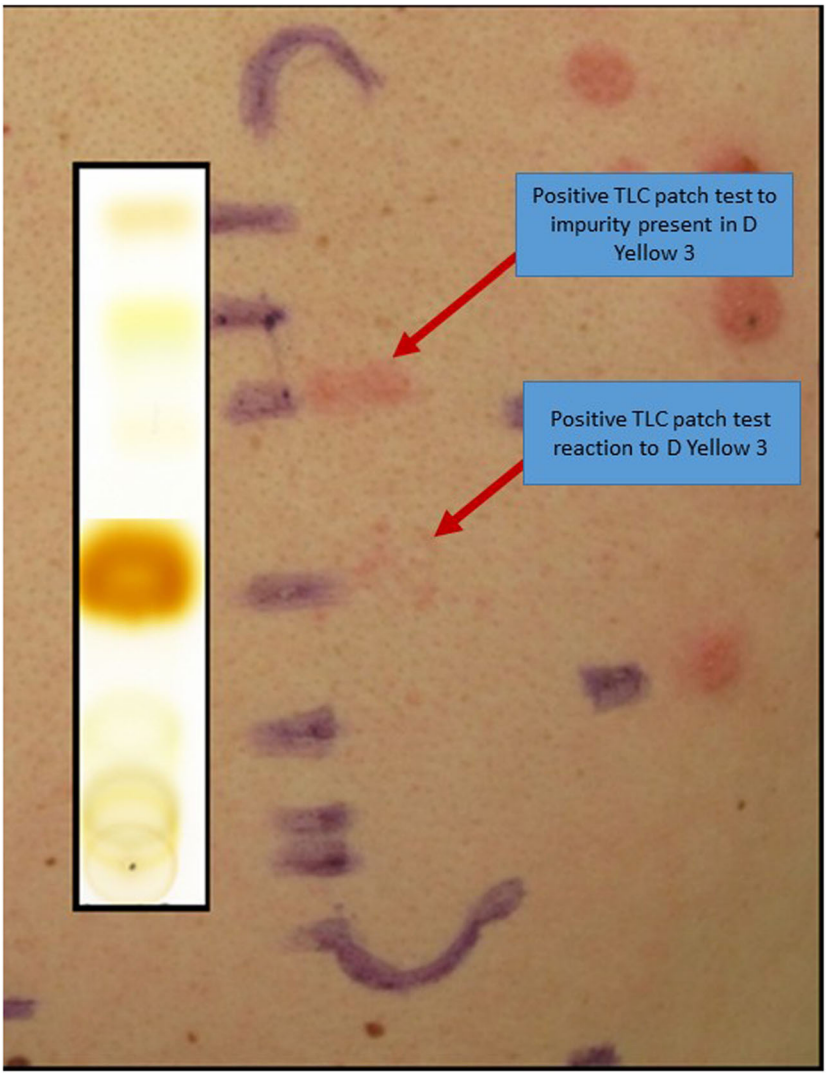

Fig. 1. Positive TLC patch test to impurity present in D Yellow 3 and positive TLC patch test reaction to D Yellow 3.

Additionally, Disperse Blue 35 was tested in 0.5% pet. and 0.3% pet., and Disperse Blue 106, Disperse Blue 124, Disperse Red 1, Disperse Red 17, Disperse Orange 1, Disperse Orange 3 and Disperse Yellow 3 in 0.5%, 0.3% and 0.1% pet.), prevalence values ranged from 0.4 to 6.7%. DD testing in a textile dye mix (TDM) was early suggested in Portugal by Dr. Francisco Brandão (Almada, Portugal) [48•]. Starting in 1999, a TDM composed of eight DDs was introduced into the baseline series of the Department of Occupational and Environmental Dermatology in Malmö, Sweden. After publication of data from testing in Sweden [49, 50], it was added to the Swedish baseline series.

The mix was recommended at 6.6% in 2015 for the European Baseline Series [48•]. The mix has also been recommended for the international baseline series [51]. The composition of the 6.6% wt/wt pet. mix should be as follows: Disperse Blue 35 (DB 35), Disperse Yellow 3 (DY3), Disperse Orange 1 (DO1), Disperse Orange 3 (DO 3), Disperse Red 1 (DR 1) and Disperse Red

17 (DR 17), all at 1.0% wt/wt, and Disperse Blue 106 (DB 106) and Disperse Blue 124 (DB 124), both at 0.3% wt/wt [48•, 51]. With the Finn Chambers® technique, a standardised amount of 20 mg of the pet., preparation should be used [50], corresponding to a dose equivalent to 2.2 mg TDM/cm^2.

Studies performed in Europe and the USA [48•, 51] showed that 2.1–6.9% of consecutively tested dermatitis patients reacted to a 6.6% wt/wt textile dye mix consisting of eight disperse dyes. The clinical relevance was ascertained in > 30% of the positive cases. DO 3 and PPD had a high frequency of simultaneous sensitivity. It has even been argued that the textile dye mix within the baseline series might even be with five colours, omitting DO 3 as the impression is that these patients are actually caught by patch testing with PPD and suggestions have been made that the concentration of the mix could then actually be lower [52]. However, such consideration requires that PPD is patch tested in the correct concentration [53]. In testing with DDs, late reactions are sometimes reported, and in some studies, active sensitization has been suggested [11•], while in other studies, no signs of active sensitization has been found [50]. In reports on contact allergy to DDs, there is usually a higher contact allergy rate to DDs noted in females compared to men [50]. In one study [54], a significant association was seen in females regarding contact allergy to PPD and self-reported skin problems arising from synthetic textile materials. The increased female frequency rate may be explained by a different exposure to synthetic fabrics or by the association between PPD contact allergy and allergy to DO 3 which in a large number of cases give simultaneous reactions in those sensitized [55]. From a chemical point of view, most DDs contain an azo structure. As a consequence, high frequencies of simultaneous sensitivity to DO 3, TDM and PPD, to TDM and black rubber mix and to DO 3 and PPD [56, 57] are often seen.

DDs known to cause contact allergy has only infrequently been identified in clothing [35, 54, 56]. Even though DDs seem to be used rarely in clothes nowadays, when extracts from garments [56] were compared by the use of thin-layer chromatography, similar dye patterns were seen, especially in the orange, red, blue and yellow regions of the spectrum, indicating common substances other than the eight DDs. Some of these may be allergenic [36, 56]. Recently, it was shown that TDM-positive patients react to the extracts made from the textiles not containing any of the 8 DDs present in TDM 6.6% [57]. The textile mix used today is not pure either and impurities may also explain positive reactions (Fig. 1). Therefore, even though the eight DDs included in the TDM may be used less in textiles today, the TDM is the best marker of textile contact allergy at present. For patients where textile dermatitis may be suspected, the baseline series with the textile dye mix is a major improvement. The general recommendation for patch testing when a textile dermatitis is suspected is thus the baseline series as such and supplemented with the textile series if other allergens than those in the baseline series can be suspected. When strong contact allergy to PPD and/or TDM is suspected, the tests should be placed on the arm of the patient, to facilitate early removal. The patch testing may also be supplemented with patch test of the suspected textile and extract of this. How to perform the extract has been defined elsewhere [58] and lies beyond the scope of this review. It should however be emphasised that the composition of the extract will be defined by the solvent used. A challenge test (stop and wear again) can also be used to prove allergy. The patient with a positive reaction and a dermatitis which may be explained by a textile dermatitis should be given proper information on which garments may be safe. Reading textile labels may be

important although it does not contain information about chemicals used, but knowing fibre composition and care instructions can help guessing possible allergens. Any garments manufactured from cotton, wool, silk or linen are good alternatives. If polyester garments are worn, light-coloured clothes are safer than dark-coloured one.

Conclusions

In summary, textile contact dermatitis often looks like endogenous eczema which localisation depends on intimate contact with the garment and often seen in skin folds. Such reactions are most commonly seen to disperse azo dyes, but other substances present in clothes can occasionally also induce contact allergy with exception of the fibres themselves. Testing for textile dermatitis is recommended using the European baseline series including TDM, Textile series and *own material* "as is", as well as with extracts made from it. If possible, performing chemical investigation of the textiles which is positive on patch testing can prove clinical relevance of positive tests and find new emerging allergens.

Compliance with Ethical Standards

Conflict of Interest
Cecilia Svedman declares that she has no conflict of interest, Malin Engfeldt declares that she has no conflict of interest, Laura Malinauskiene declares that she has no conflict of interest.

Human and Animal rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

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