

SKIN ALLERGIES IN THE CONSTRUCTION INDUSTRY

N van de Water | MBChB, DOH

Division of Occupational Medicine, School of Public Health and Family Medicine, University of Cape Town

Email | nickvdw@gmail.com

ABSTRACT

Although allergies cause only about 15% of occupational diseases, in the building and construction industry they constitute the most common occupational diseases – in particular, allergic contact dermatitis.^{1,2} This article explores three agents found on a battery of commercial allergens commonly used for standard patch tests to which a self-employed carpenter was found positive: potassium dichromate, paraphenylenediamine (PPD) and para tertiary butylphenol formaldehyde resin (PTBP-F-R). It explores the carpenter's likely exposures to these agents in the construction industry and uses them as examples to illustrate the tenets of occupational medicine and the approach to be taken even when specific causative agents cannot be identified. Specifically, the article looks at the hierarchy of controls and its appropriate application, from the most effective – elimination and substitution – to the least effective – the use of personal protective equipment (PPE). The use of PPE results in a reduction in sensitisation rates. However, the use of inappropriate PPE could possibly worsen the current problem or cause other sensitisations.

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CASE

A 50-year-old male carpenter presented with an 18-month history of an intermittent rash on the hands and exposed skin areas. The rash had initially been extremely itchy with erythema and scaling. He had also developed a rash on his right flank where a laminated-wood beam had come into contact with the exposed skin between his shirt and pants, and he attributed his rash to contact with the beam and dust exposure during on-site installation of a set of steps. The gentleman was treated with oral prednisone, which resolved his symptoms completely.

After the initial resolution, the gentleman had a few asymptomatic months, after which the same rash recurred on his hands and forearms. He again attributed it to contact with a laminated pine beam, which he had used in the on-site construction of a basic carport. Despite the use of multiple over-the-counter remedies, his rash did not resolve completely.

Three months prior to his initial consultation at our occupational dermatology clinic, he developed lesions on his feet for the first time. The rash started bilaterally with dorsal erythema and later skin thickening, followed by maceration and weeping. The plantar aspects of his feet had marked thickening of the skin. He also reported itching and an erythematous rash on the back and buttocks and in the axillae. Because of a worsening rash on his hands and severe secondary infection with weeping of his feet, he was admitted to hospital.

During his inpatient admission he received super-potent topical corticosteroid under wet wraps and Ciprofloxacin for the infection. His skin responded well and he was discharged 13 days after admission. A patch test with 45 commercially available allergens commonly causing contact allergy was done. The patch test was read 72 hours after application and 24 hours following the patch-test removal in accordance with the Contact Dermatitis International Research Group Guidelines.³ The positive results and their relevance to his clinical condition are summarised in Table I.

On presentation at our occupational dermatology clinic, the gentleman had bilateral fissuring of his hands with dryness, scaling and lichenification. He also exhibited bilateral hyperkeratotic soles with post-inflammatory hyperpigmentation (see Figure 1) as well as a small patch of active dermatitis on his lower back. It was established that the gentleman had been working in the construction industry for 30 years – his entire working career. For the past 11 years he had been a self-employed carpentry sub-contractor. This could involve anything from working with roofing timbers to the installation of door frames. His timber is all brought on-site pre-cut and ready for installation, with the prefabrication taking place in his workshop off-site. In the past 18 months he has noticed that, when working with laminated pine in particular, he has developed a rash which resolved with time away from work. On the basis of his history, examination and patch-test results, a provisional diagnosis of occupational ACD was made.

Unfortunately, due to the fact that the gentleman had worked on multiple sites, it was logistically impossible to do a work visit to assess his exposures. In addition, owing to his financial difficulties, he had lost his workshop premises. A follow-up own-product patch-test was performed in an attempt to identify the source of exposure in his workplace. Nitrile gloves; cotton gloves; leather from the tongue of his shoe; rough pine sawdust (untreated); gum pole sawdust (treated); laminated pine beam sawdust (treated) and Garapa (Brazilian Ash) sawdust were all unreactive.

INTRODUCTION

Data from studies done in 1994 in Finland have suggested that marginally less than 15% of all occupational diseases are allergy-related.¹ In construction workers specifically, allergies are reported in almost all instances as either

work-related asthma or ACD. Contact dermatitis is the most frequently reported occupational disease among workers in the building and construction industry^{2,4} with tile setters at 19.9 per 100 000, painters at 7.8 per 100 000, construction and cement workers at 5.2 per 100 000 and wood processors at 2.6 per 100 000 recorded in Northern Bavaria (2003).⁵ In Brazil, it was found that the five most common allergens among construction workers between 2000 and 2005 were potassium dichromate (57%), carbamix (34.9%), cobalt chloride (30.2%), thiuram-mix (27.9%) and neomycin (19.8%).⁶ No data is available for workers in the construction industry in either Africa or, more specifically, South Africa.

I discuss the three main allergens that were identified in our case, highlighting their chemical properties, uses in



Figure 1: The patient's hands and feet. The palms (a) and soles (b) show marked hyperkeratosis and hyperpigmentation with fissures of hyperkeratotic eczema. The dorsal surfaces of the hands (c) and feet (d) show vesico-papules and crusting on a background of erythematous lichenified skin.

TABLE I: PATIENT'S POSITIVE PATCH-TEST RESULTS

3+	Potassium dichromate	Significant allergen for construction workers found especially in cement.
2+	Paraphenylenediamine (PPD)	Possible allergen for construction workers found in black rubber and in black dyes.
3+	Para tertiary butylphenol formaldehyde resin (PTBP-F-R)	Possible allergen for construction workers but more likely a shoe allergen.
1+	Neomycin sulphate	Non-significant allergen for construction workers; possible exposure from prescribed topical preparations.
1+	Chloroxylenol (PCMX)	Non-significant allergen for construction workers; possible exposure from Dettol®.

the construction industry and ways in which exposure can be minimised. It must, however, be remembered that the construction industry is a very wide field when one considers the tasks performed and rate of exposure to substances (see Table II).

POTASSIUM DICHROMATE

CHEMICAL PROPERTIES AND USES

Potassium dichromate is found in many processes in the construction industry. Specific exposures are from cement, wood preservatives, wood stains, glues, paints and tanned leather (used in shoes, gloves).^{12,13} Chromium compounds are used mainly because of their corrosion-resistance, durability and hardness. The chemical formula for potassium dichromate is $\text{Cr}_2\text{K}_2\text{O}_7$, where each chromium molecule forms two double and two single ionic bonds with oxygen (see Figure 2). This is the hexavalent form of chromium, notated as Cr^{6+} (Cr (VI)). Chromium may be found in other valence states, the most common being trivalent chromium, Cr^{3+} (Cr (III)).

The predominant form of chromium found in cement, Cr (III), is mostly stable and has little effect on the environment and living organisms.¹⁴ Although Cr (VI) is not the predominant form, it has received most attention because of its effects on health and its ability to cause ACD. Job categories exposed to wet cement include bricklayers, cement masons, concrete finishers, brick carriers, plasterers and tile setters.¹³ One of the hallmark studies showing the association between cement work and ACD was that carried out on the workers constructing the Channel Tunnel. There, 17% of the grouters of this workforce were found to have a positive patch-test for

potassium dichromate.^{15,16}

Wood has for a long time been preserved with heavy metal-based preservatives such as chromate-copper-arsenate (CCA). This has been in part due to the lack of a suitable alternative.¹⁷ The process involves wood impregnation by the chemical under cycles of pressure and/or vacuum. Some residue of the preservative may be left on the surface of the wood and skin contact with the chromium (Cr (III)) occurs in this way. This is similar to skin exposure from stains, glues and paints (Cr (III) and Cr (VI)).

It is thought that Cr (VI) is the main culprit in ACD; however, there is some evidence that, especially in leather exposure, both Cr (III) and Cr (VI) have a role to play in the development of allergy. The leather found in work shoes and protective gloves is tanned. The tanning process uses chrome sulphate (Cr (III)), which binds with collagen to stabilise the leather. However, some Cr (VI) may be found in the final product as a result of the spontaneous oxidation of Cr (III) to Cr (VI). The Cr (III) remains bound to the leather collagen because of its high protein affinity,¹⁵ but Cr (VI) is leached from the leather and becomes bioavailable with sweating. The Cr (VI) then penetrates skin relatively easily and is transformed into Cr (III), which in turn binds to protein due to its high protein-binding affinity and creates the protein-hapten allergen that leads to sensitisation.¹⁴

PREVENTION

Unlike most of the other sources of chromium exposure, the production of cement does not specifically add or use chromium. The chromium found in cement is a by-product of the production process. The potential sources for chromium contamination include these raw materials:

- limestone and clay;
- the fuels used to heat the kilns;
- the refractory bricks used in the kilns;
- the grinding media; and
- additives such as gypsum, pozzolans, ground-granulated blast-furnace slag, mineral components, cement kiln dust and set regulators.¹⁴

The amount of chromium in the cement therefore varies and is not only directly related to the quantities in the mix but also to the conditions in the kiln during the manufacturing process.¹³

The most logical preventive strategy would be to reduce the amount of chromium in the end-product to an absolute

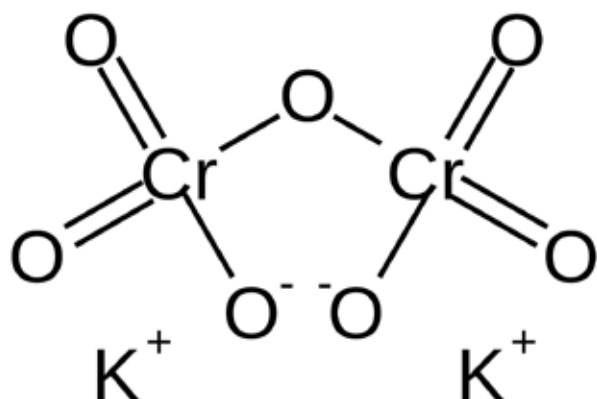


Figure 2: Chemical structure of potassium dichromate

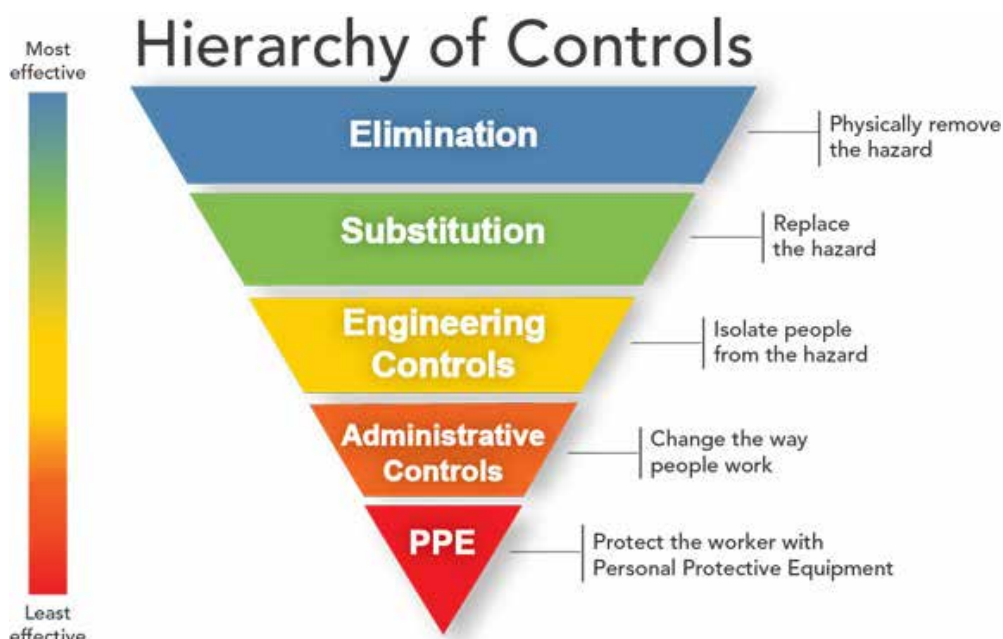


Figure 3: Hierarchy of controls for hazard avoidance²¹

minimum during the manufacturing process. In the hierarchy of control, exposure should in the best-case scenario be eliminated and in the worst case merely be barriered by personal protective equipment (PPE) (see Figure 3). To this extent, manufacturers and regulatory bodies have gone to great lengths to reduce the amount of Cr (VI) in cement. One such method is to include additives that bind or prevent the formation of Cr (VI), such as ferrous sulphate.¹³ Another is legislation such as the controlled limit found in the hazardous chemical substances (HCS) regulations attached to the Occupational Health and Safety Act of South Africa. The limit is set at 0.05 mg/m³ on a time-weighted average (TWA) over 8 hours.¹⁸ The reduction in concentration of Cr (IV) in cement has been shown to be very effective in Germany. The chance of a worker employed in the building industry after 1999 becoming sensitised to chromate is less than half of that for workers employed before 1994.¹⁹ It is now legislated in the European Union that no cement should be supplied or used if it contains more than 2 ppm Cr (VI) and the South African national standard is a copy of the European standard.²⁰

The prevention of exposure to chromium in wood preservatives is also possible through elimination and substitution of the products containing chromium. In recent years much progress has been made toward the use of alternate wood preservatives in place of heavy metal preservatives. These organic products are mostly in the research phase, although some have made it to market.^{17,22,23} In South Africa it is now common to find that wood purchased at major retailers will have been treated with a product which does not include chromium as a key ingredient. The avoidance and substitution of stains, paints and glues containing chromium is mostly possible because

suitable alternatives are now also available in the market.

Leather products are one of the sources of Cr (VI) exposure and often employers give them to their employees as PPE in order to protect them. A reduction in sensitisation to chromium has been shown in some studies with the use of PPE, but this has been accompanied by an increase in the sensitivity to allergens found in the protective equipment – such as rubber gloves.²

It is for this reason that clinicians should be aware of the risk involved in prescribing PPE and highlight PPE as being the least-effective form of control. The importance of using alternative products should be emphasised in order to prevent exposure.

PARAPHENYLENEDIAMINE

CHEMICAL PROPERTIES AND USES

PPD is an organic compound with the formula C₆H₄(NH₂)₂. The compound is most commonly known as an 'occupational dye allergen' among hairdressers. In the construction industry, one might encounter contact with PPD when handling rubber products. Some case reports suggest that previous exposure to non-permanent henna tattoos has sensitised patients to PPD and they have later presented with the occupational allergy.^{24,25} PPD is the most effective antioxidant, anti-flex-cracking agent and anti-ozonant for rubber in flexing and static positions. There are many derivatives from PPD; fortunately, some of these have been banned due to their toxic effects, despite their better efficacy.²⁶

In a study from northern Italy, which included 14 464 patients, 4.7% of females and 2.7% of males employed in the building and related trades were found to be sensitive

TABLE 2: COMMON ALLERGENS IN THE CONSTRUCTION INDUSTRY⁷⁻¹¹

Carpenters: • Woods: - pine (colophony) - imported hardwoods • Wood preservatives and treatments: - preservatives (CCA) - epoxy/acrylic resins and hardeners - glues/adhesives
Labourers, masons and plasterers: • Cement • Concrete
Painters: • Paints or varnishes • Solvents or additives • Resins
Plumbers: • Welding fumes • Resins • Cleaners (Formaldehyde)
General: • Personal protective equipment: - gloves (rubber, leather, latex) - leather boots

to PPD on patch-testing. Despite the large numbers in the groups (214 in the female group and 313 in the male group of building and related trades), a statistically significant odds ratio for sensitisation was not found compared to the findings for office workers as the reference group.²⁷ Other sources of PPD sensitisation have been reported from exposure to textiles, shoes, gloves and black rubber.²⁸

PREVENTION

Although there is no legislation banning the use of PPD outright, there are guidelines, which indicate the levels of exposure that are acceptable. American guidelines set by the National Institute for Occupational Safety and Health recommend a time-weighted average (TWA) of 0.1 mg/m³ contact with the skin.²⁹ The South African legislation, namely the HCS regulations, has adopted the same recommended limit as the American standard.¹⁸

As always, the last resort to protect a worker should be the use of PPE, especially in the case of PPD allergy because of possible PPD exposure in the PPE.

PARA TERTIARY BUTYLPHENOL FORMALDEHYDE RESIN

CHEMICAL PROPERTIES AND USES

PTBP-F-R is found in many adhesives and is used as a binder. It can also be found in plywood, insulation and glues. Most commonly, it is used to bond rubber or leather products and would be found as the glue in shoes.¹² Other sources of PTBP-F-R exposure include the production of fibreglass, the installation of mineral fibre (mostly for insulation purposes), the manufacture of laminated woods and surface coatings, including varnishes.³⁰

One of the great difficulties in isolating a specific work

process or item as the causative agent in sensitisation to PTBP-F-R is that there is cross-reaction between related chemicals. One such chemical is phenolformaldehyde resin (PF-R). It has been shown that a positive reaction to PF-R occurs in 65.8% of patients who were known to have positive patch tests to PTBP-F-R.^{31,32} As such, it is advised to further test patients with PTBP-F-R positive patches if they do not have any obvious contact with the resin.³³ PF-R is found in many products that contain PTBP-F-R; but what is unique to PF-R is that it is used in metal-casting sand.¹²

PREVENTION

As always, the best preventive measure is to avoid the product totally. Special gloves are available for protection from resins; however, it has been shown that the use of any glove reduces sensitisation rates.³³ Unlike the first two allergens discussed in this article, there are no prescribed limits to PTBP-F-R in the HCS regulations.

CONCLUSION

The 50-year-old gentleman mentioned in the case is exposed to all of the above-mentioned allergens in the workplace, and most likely in multiple ways too. At the time of writing, we have not yet found a positive patch to specific work exposures due to a lack of information about the products he uses and because of the limited number of work and PPE substances patch-tested. Some specific exposures may never be confirmed because cement dust is ubiquitous on a construction site and could easily contaminate the wood he uses even though it was prepared off-site. This could account for his chromate allergy. In the light of his original positive patch-test results, further specific tests for potassium dichromate could include wood stains, preservatives, glues and paints; for PPD, black rubber from tools and power tools; and for PTBP-F-R, glues, varnishes, mineral fibres and laminate wood glues to which he is exposed. Neomycin has been shown to be a relatively common allergen in construction workers in Brazil and has been attributed to topical prescribing practices.⁶

Our patient showed a 1+ positive reaction to neomycin, probably owing to the topical products used to treat his skin. Ongoing neomycin exposure should be excluded as it could account for the persistence of his skin condition.

Unfortunately for the gentleman, avoiding allergens has proved difficult and he continues to have flares despite optimal therapy. Also, there is no possibility for compensation from the Compensation Commissioner as he is a self-employed contractor. He is reliant on his income to support himself and his dependants and cannot simply stop working or change his profession. However, he is mostly unable to work as a result of the discomfort experienced through the flaring of his symptoms.

The overarching theme of this case is the risk to the small

firm or the self-employed, where an insufficient budget is allocated for occupational health and safety aspects in order to make a reasonable profit. This in turn does not allow these people to use the 'gold standard' of avoidance of the allergen in its entirety. Although this is not ideal, when the absence or elimination of the product is not possible, the correct PPE can reduce flares and sensitisation rates.³³

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DECLARATION OF CONFLICT OF INTEREST

The author declares no conflict of interest.

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