

Hair dye sensitivity testing: a critical commentary

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Summary

Although the large majority of users do not experience adverse skin reactions to hair dye products, a minority do. Most serious among these are allergic skin reactions, commonly to *p*-phenylenediamine and its derivatives. The consumer or hairdresser is expected (by the manufacturer) to limit the chance of expression of allergy by conducting a 'sensitivity test', which should provide the consumer with an alert for possible allergic reactivity. However, a self-conducted consumer test can only be useful if it meets a number of important criteria, including evidence that the test protocol works, that it can and is likely to be used successfully by the consumer or hairdresser, and that it does not present a significant health risk (e.g. an increased risk of developing allergy). In short, as with any *in vivo* test, the benefit must outweigh the risks. In formulating such a test, it should be determined in advance what are the acceptable levels of specificity (correct identification of negatives) and sensitivity (correct identification of positives). It is our view that any hair dye sensitivity test, whether supplied by the hair dye manufacturer or a third party, should be able to answer these questions.

Key words: cross-reaction; hair dye; *p*-phenylenediamine; sensitivity test.

There is an extensive body of clinical literature showing that allergic contact dermatitis caused by hair dyes is a significant, probably increasing, occupational and consumer health problem (1–4). Allergy to hair dye is not a new phenomenon, having been reported for many decades (5, 6), and hairdressers are commonly high on the list of those with occupational dermatitis (7–9). Investigation of those with dermatitis in that industry shows that a significant number have hair dye contact allergy. Among consumers, the currently available evidence suggests that although >90% of hair dye users do not experience allergic reactions, several per cent may do so (1–4, 7). However, of concern for the future is the apparent intensity of sensitization to *p*-phenylenediamine (PPD) that is occurring in children (10).

It is of significance that almost all of the hair dye work has been completed with just a single marker hair

dye allergen, PPD. Indeed, the present evidence suggests that although PPD might not be responsible for all cases of hair dye allergy (11, 12), the fact that it cross-reacts so well with other commonly used hair dye allergens [e.g. toluene-2,5-diamine (PTD) and the aminophenols] makes it an effective marker of the majority of hair dye allergy problems (13, 14). This also is consistent with the evidence from *in vitro* T lymphocyte stimulation studies, where two-thirds of T cell clones reactive to PPD also responded to PTD, as well as being consistent with the results from *in vivo* models (15–18). However, it has been shown that there are some individuals with hair dye allergy who do not have a positive response to PPD (11, 12, 18). Recently, a survey of oxidative hair dyes on the Swedish market concluded that the use of a number of potentially sensitizing hair dyes is now more prevalent than the use of PPD, and that screening chemicals other than PPD should be incorporated into diagnostic patch test series (19). Nevertheless, the most prevalent of these (PTD and *m*-aminophenol) are substances that are known to cross-react well with PPD.

Given the widespread use of hair dye by consumers, it is of note that a substantial proportion of those with

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allergy (perhaps as many as 75%) continue to dye their hair, perhaps tolerating a modest degree of discomfort in order to obtain the cosmetic benefit (20). However, a minority of those with hair dye allergy experience much more substantial reactions, including a number with very severe responses (1, 7, 20, 21). To limit the extent of consumer risk of allergic reactions, the hair dye industry has, for many years, promoted the concept of a hair dye sensitivity test to be used by/on consumers, 48 hr prior to dyeing their hair (22). Studies have been undertaken that aimed to demonstrate the efficacy of such an approach (23, 24), but these are limited in scope, and fail to address a number of important questions, including whether use of the consumer test itself increases the risk of the induction of allergy or exacerbation of reactivity. In this short article, we consider the aim and scope of hair dye sensitivity testing, presenting what we judge to be the most critical questions that should be answered before such testing is conducted. Whether hair dyes themselves present an unacceptable safety risk, occupationally and/or to the consumer, is outside the remit that we have set ourselves, but it remains a fair question – hair dye products with a more acceptable level of allergenic potential would probably preclude any need for consumer sensitivity tests.

Hair Dye Sensitivity Testing – the Current Situation

Perhaps first and foremost, it is necessary to state clearly that this type of testing is in no way a substitute for a proper process of diagnostic testing and clinical assessment by a trained dermatologist. It might best be thought of as an allergy alert, which, if positive, should be taken as signal to avoid hair dyeing and seek further medical advice.

At present, there is no formally agreed/consistent approach recommended by the hair dye industry for the conduct of sensitivity testing. The following method has been reported by one company (23, 24). It involves the placement of a small quantity of formulated hair dye onto the skin behind the ear, followed by assessment of any reaction at 48 hr post-application. In these experimental studies, hair dye was applied without mixing with oxidative developer. Consequently, at the currently maximum allowed use level of 4% (equal to 2% on the head after admixture with developer), and with the 0.1 ml dose applied to the suggested 1.75 cm² of skin, the dose per unit area of PPD could approach 2300 µg/cm², although this may be mitigated to some extent by the absence of occlusion. Nevertheless, this level is 10-fold higher than that used in a standard diagnostic patch test (1% PPD, 20 µl, 0.5 cm² chamber size). These two studies were performed

under full clinical control, and showed that, for a range of PPD concentrations, this approach could elicit allergic skin reactions in subjects known to be sensitized to this hair dye allergen (23, 24). In the earlier study, no indication was given of the pre-existing sensitivity of the 30 subjects; for the later study, only 2 of the 34 subjects were weakly sensitized to PPD. Avoidance of weakly sensitized individuals, of course, increases the chance of obtaining positive results. However, it also leads to a key question discussed later in this article: who is the target subject?

Other proposals on how to undertake hair dye sensitivity testing have appeared in more modern forms of communication. For example, an online video confirms the importance of carrying out such a test, but fails to provide meaningful details, such as the proportions in which to mix hair dye and developer, the quantity to apply to the skin, or how to evaluate the results (<http://www.youtube.com/watch?v=QjWsfmnddLI>) (25). Interestingly, in this case, the company behind the video suggests mixing of the hair dye and developer, in contrast to the recommendations published (23, 24). Also in contrast to the published procedure, the approach shown in the video does use occlusion to a skin site (the antecubital fossa). The video assumes an absence of reaction, which therefore permits hair dyeing to proceed. Presumably, by default, any type of skin response on the test site is meant to communicate an allergy alert, which should preclude hair dyeing.

In 2004, a UK-based company developed and marketed a patch test kit (Colourstart®; Trichocare Diagnostics Ltd, Ridgmont, UK) for use by hairdressers. It was intended to assess whether clients have a 'problem with hair dye', and was promoted as the 'only practical solution to sensitivity testing'. One of the authors (D.O.) first became aware of this when he saw a patient who had used this test system and who described the result as negative, but who went on to develop an allergic reaction to an oxidative hair dye. The test consisted of a temporary transfer containing PPD and resorcinol. It is recommended that the transfers be applied to the inner arm (close to the elbow joint) 48 hr before the client attends the salon.

In the presence of unusual sensations, irritation, redness, or swelling, 'the client is advised that they are hypersensitive and should not have their hair dyed'. A small study was conducted on consecutive patients presenting with a history of adverse reactions to hair dyes and assessing results with Colourstart® in parallel with the commercially available hair dye patch test reagents (26). The results showed that, at the very best, only 3 of 7 cases were detected with Colourstart® while having positive relevant allergic reactions to conventional hair dye patch test reagents. In addition, another

case whose primary relevant allergen was PTD was not identified with the Colourstart® patch tests. The study concluded that whereas Colourstart® was commendable for improving convenience it might be insufficiently sensitive for consumer protection. A subsequent study concluded that it successfully identifies those individuals (83% of those reporting a severe/very severe history of a hair dye adverse reaction) with the greatest sensitivity to PPD who might be at risk of a severe reaction if they dyed their hair (27). It also found that 'this system's ease of use is likely to contribute substantially to compliance'. Nevertheless, one-third of the PPD patch test-positive subjects recruited for this study had not experienced any adverse reactions to hair dyes or been exposed to black henna tattoos. Furthermore, 30% of subjects with weakly positive patch test results (+) reporting severe or moderately severe hair dye reactions were not detected with Colourstart®, and 1 patient with a weakly positive PPD patch test reaction and no history of adverse reactions to hair dye had a positive Colourstart® test result.

Perhaps the most appropriate place to find instructions for self-testing with hair should appear on the hair dye packs themselves. Inspection of such packs from two major manufacturers indicates that, at this level, the matter is taken seriously – an example is provided in Fig. 1.

Hair Dye Sensitivity Testing – the Issues

After the primary question of whether it should be necessary/performed at all (which we have noted as being

outside the scope of the present discussion), it is necessary to be clear about whether the aim of such testing is to identify 100% of individuals with any type of contact allergy relevant to hair dye or whether, in fact, the aim is to identify individuals with contact allergy to hair dye and who may be at risk of a more severe type of allergic reaction (or, of course, whether the aim is, in reality, somewhere between these two extremes). It is our view that achieving 100% accurate identification of all at-risk individuals might seem to be an ideal goal, but it is not one that is likely to be practicable, and it may increase the potential risks to consumers (see below). Probably, it is more appropriate to attempt to provide an alert to those who are most at risk of having a strong allergic reaction.

In the light of the stated aim of the sensitivity test, it then follows that it is necessary to show that any particular chosen system works with a sufficient degree of accuracy. Some work in this regard has been presented, both by a hair dye manufacturer and by an independent manufacturer of a test kit designed for the purpose (23, 24, 27). The authors of this present article have been involved with aspects of this work. The studies have all made use of dermatology patients with a proven history of contact allergy to PPD, meaning that no approach has been shown to work in individuals with hair dye allergy that is not caused by either PPD or one of its cross-reacting substances. In the most recent study (14) with 30 volunteers, a self-test identified 10 of 10 (100%) of those with a +++ patch test reaction to PPD, 8 of 10 (80%) with a ++ patch test reaction, and 1 of 10

SAFETY INSTRUCTIONS: READ BEFORE USE

**SKIN ALLERGY TEST : MUST BE DONE 48 HOURS BEFORE EACH APPLICATION
EVEN IF YOU HAVE ALREADY USED A HAIR COLOURANT.**

SKIN ALLERGY TEST

IMPORTANT: HAIR COLOURANTS CAN CAUSE AN ALLERGIC REACTION WHICH IN CERTAIN RARE CASES MAY BE SEVERE. TO HELP YOU REDUCE THE RISK OF AN ALLERGIC REACTION, IT IS THEREFORE ESSENTIAL TO FOLLOW THE PRECAUTIONS BELOW:

- **DO NOT USE:**
 - If you have already had a reaction to a hair colourant.
 - If you have an itchy or damaged scalp.
- **BLACK HENNA TATTOO:** if you have ever had a black henna tattoo, even a long time ago, you are very likely to have become allergic without realising it. Take no risk. **Never use this product unless you have done the skin allergy test 48 hours before use.**

IT IS NECESSARY THAT YOU PERFORM A SKIN ALLERGY TEST 48 HOURS BEFORE EACH USE OF THIS PRODUCT, AS AN ALLERGY CAN DEVELOP SUDDENLY, EVEN THOUGH YOU HAVE PREVIOUSLY USED A HAIR COLOURANT OF THIS OR ANY OTHER BRAND.

HOW TO PERFORM THE SKIN ALLERGY TEST:

- Remove earrings. Behind the ear and using a cotton-bud apply a little of the unmixed colourant product (bottle B) of the colourant gel) sufficient to cover an area about the size of a penny. Re-apply two or three times allowing it to dry between each application. Carefully reseal the colourant container.
- Leave for 48 hours **without washing, covering or touching.**
- If during this period you notice any abnormal reactions – such as itching, redness or swelling in or around the test area, **DO NOT APPLY THE PRODUCT.**

SPECIAL PRECAUTIONS

- **IN CASE OF A REACTION DURING THE APPLICATION** such as intense stinging, irritation, rash or burning sensation on the scalp, rinse immediately with lukewarm water and discontinue use. If you experience shortness of breath, seek immediate medical attention. Before colouring your hair again, consult a doctor.
- Avoid contact of the product with skin and eyes. Do not use to dye eyelashes or eyebrows. To do so may cause blindness.
- Rinse eyes immediately if product comes into contact with them. If you wear contact lenses, take them out before rinsing your eyes thoroughly with water.
- Wear the gloves supplied in the carton.
- Rinse hair well after application.
- Do not inhale or ingest.
- Prepare and apply the mix preferably in a well-ventilated place.
- For all questions concerning your individual sensitivity, consult your doctor.
- Do not use on a beard or moustache or for any other purpose than colouring your hair.
- Do not use on relaxed hair or immediately after lightening the hair for shades 10, 10.1, 10.13.
- Wait at least two weeks after lightening or relaxing the hair before applying the hair colourant.
- Do not use if your hair has been coloured with henna or with a progressive colour.
- Keep out of reach of children. Do not use on children.

FOLLOW THE INSTRUCTIONS FOR USE

Fig. 1. An example of a manufacturer's warning and self-testing instructions.

(10%) with a + patch test reaction. Now let us compare these results with those for patients who have a positive history of experience of reacting to hair dyes. In this group, 32 of 38 (84%) of +++ patch test reactors gave a history of hair dye reactions, and 119 of 167 (71%) of ++ patch test reactors and 110 of 193 (57%) of + patch test reactors also gave a history of reacting to hair dyes. When Fisher's exact test (GRAPHPAD) with two-way variables is applied to compare a positive self-test result with a positive history, we find no statistical difference in the +++ or ++ reactors, and a highly statistically significant factor in + reactors, where a positive history is more reliable than the self-test (+++ group, $p = 0.3203$; ++ group, $p = 0.72$; + group, $p = 0.0059$). Finally, it should be noted that, although false-positive reactions are unlikely, no data exist on the specificity of any of the current hair dye sensitivity tests.

At present, although information is limited, it is generally concluded that only a small minority of consumers actually undertake a sensitivity test prior to each hair dyeing process, despite clear advice from the manufacturer that this should be done. The reason(s) why this may be the case are far from clear, but are likely to include poor user-friendliness and the absence of a culture of sensitivity testing in hairdressing salons. In one UK population-based study looking at the use and reported adverse reactions to hair dyes, although the consumers were aware of the suggestion to perform a sensitivity test (86%), only 5% used it on a regular basis (28), half the already low estimate made elsewhere (27).

Assuming that the sensitivity test is performed, whether by the consumer or the professional hairdresser, it is necessary for there to be clear guidance on the interpretation of the results. Those performing the test are unlikely to be either dermatologists or generally trained in the assessment of allergic skin reactions. Thus, a pictorial guide to what a positive reaction will look like is an absolute necessity. Also, that guidance must be appropriate for a multiethnic society. Arguably, where the testing is performed by a hairdressing salon professional, that individual should be suitably trained and have evidence of maintenance of a quality standard. A difference in the ease of the interpretation of Colourstart® was implied in the two studies performed to date (26, 27). It is also noted that a positive result should not only cause a consumer not to proceed to hair dyeing, but can also indicate the need for a formal medical consultation.

Above and beyond these basics, and particularly if the aim of the sensitivity test is to provide an alert for any degree of contact allergy to hair dye, then a considered analysis of whether and how other factors, for example concurrent medication and ultraviolet exposure, might

affect the results is necessary. This could reduce the chances of a false-negative result being obtained.

Finally, it is important to establish that the hair dye sensitivity test is generally safe for the consumer. This means that it is necessary to understand the relative additional risk of the induction of skin sensitization that such a process will confer. In this context, it must be the case that use of a high dose of hair dye allergen, with prolonged and repeated exposures, will contribute to this risk. Consequently, strategies for a sensitivity test that limit exposure to the absolute minimum necessary to achieve the stated aim of the test, or at least to a level that presents the lowest additional risk, are to be favoured. Indeed, a demonstration of risk/benefit should be carefully considered, an aspect raised by a recent suggestion that such a test should identify only those with a potentially more serious level of hair dye sensitivity (28).

Conclusions

'Hair coloring products present no health risk for the consumer when used as directed on the product label' (29). This statement seems to be inconsistent with the reality of consumer experience (1–4, 6, 7). Furthermore, if it was taken at face value, then a sensitivity test to detect hair dye allergy would carry no benefit, making it hard to understand why manufacturers continue to recommend its use prior to every hair dyeing activity. Perhaps allergy is not seen as a health risk. Furthermore, a sensitivity test based on application of a poorly defined blob of hair dye mixture with little guidance/training on the interpretation of skin responses, as is the present situation, is unlikely to be able to address the issues outlined, including those related to safety. In reality, the manufacturer's statement above takes into account that all those at risk of an adverse reaction have performed a sensitivity test and decided not to proceed to dye their hair. So, if a consumer hair dye sensitivity test is worth performing, and assuming that it is safe and effective, then, to achieve this aim, it must be performed in a thorough manner by all those intending to dye their hair. If it is not safe, or the risk/benefit cannot be demonstrated, then a sensitivity test should not be advocated by the industry. Further studies, if appropriate, should address sensitivity, specificity (in comparison with the subjects' perception of already reacting to hair dye), safety, specifically the theoretical dangers of active sensitization and a false sense of 'safety' (i.e. false-negative test result), and the reliance on subjects not going ahead with hair dyeing, even when faced with a positive test result.

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