

ORIGINAL ARTICLE

Contact allergy to hair cosmetic allergens in Thailand

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Abstract

Background: Hair cosmetics such as hair dyes, bleaching, waving, and cleansing products are composed of numerous chemical ingredients. Allergic reactions to these contact allergens, other than *p*-phenylenediamine, are rarely reported.

Objectives: To study the incidence of patch test reactions to hair cosmetic allergens and identify the factors associated with hair cosmetic allergy in Thailand.

Methods: We retrospectively reviewed the case records of patients who underwent patch testing from 2009 to 2018. Patients with at least one positive patch test reaction to a potential contact allergen associated with hair cosmetic ingredients were studied.

Results: Overall, 2842 patients were patch tested. Of the hair cosmetic allergen categories, preservatives had the highest rate of positive reactions, followed by surfactants and hair dyes. Perming agents were less problematic in comparison. The hands, head, and neck were the predominately affected sites of allergic reactions to hair cosmetic ingredients.

Conclusions: Preservatives, surfactants, and hair dyes are important contact allergens, whereas perming agents are less likely to cause allergic reactions. Hair cosmetic ingredients are regulated by national agencies, which influences their extent of exposure and rates of contact allergies. Further continuous observation of hair cosmetic allergy is needed to provide the best patient care.

KEYWORDS

allergic contact dermatitis, contact allergy, hair cosmetics, hair dyes, scalp dermatitis

1 | INTRODUCTION

The demand for hair cosmetics and other hair care products has been increasing. The global market for hair care products is the second largest area after skin care cosmetics.¹ Hair cosmetics can be classified into (a) cleansers, (b) conditioners, (c) fixing/style control, (d) coloring or bleaching, and (e) waving or relaxing products.^{2,3} These hair cosmetics contain various contact allergens. Hair dyes have been reported to be important contact allergens, some of which are categorized as strong sensitizers.^{4,5} Sensitization to hair dyes, namely

p-phenylenediamine (PPD), remains an important cause of allergic contact dermatitis (ACD) in many countries.^{6,7} Market surveys of hair coloring products suggest that the constituents used vary according to geographic region.⁸⁻¹⁰ For example, the primary intermediate PPD is more commonly used in Thailand⁸ and the United States,¹⁰ whereas toluene-2,5-diamine (sulfate) (TDA) is more popular in Europe.⁹ Therefore, exposure and sensitization rates to these chemicals in different product formulations vary by country and over time. Other chemicals (including oxidizing substances, waving agents, surfactants, fragrances, and preservatives) also have the potential to cause ACD in both

consumers and hairdressers.^{11,12} The objective of this study was to determine the incidence rates of contact allergies to those hair cosmetic ingredients in Thailand from 2009 to 2018.

2 | MATERIALS AND METHODS

2.1 | Study population

A retrospective chart review of clinical and patch test data was performed on patients at the Contact Dermatitis Clinic, Siriraj Hospital, from 2009 to 2018. Patients with at least one positive patch test reaction to a potential contact allergen associated with hair cosmetic ingredients were studied. The Siriraj Institutional Review Board approved the study (Si498/2015).

The recommendations of the ESCD guideline were used as a reference to include the patients with suspected ACD for patch testing at our clinic.¹³ Accordingly, 2842 patients were patch tested with our baseline series, which was a modification of the European and International baseline series, during the study period.¹⁴ Additional allergens in our hair dressing series were used for the patch testing 153 patients with suspected ACD to hair cosmetics. Regarding the change of allergens in our baseline and hair dressing series throughout the study period, the numbers of tested patients with individual allergens partly varied (Table 1). The 25 hair cosmetic-associated allergens were classified into four groups: hair coloring agents, perm compounds, preservatives, and surfactants. The allergens (Chemotechnique Diagnostics, Vellinge, Sweden) in aluminum Finn Chambers (SmartPractice, Phoenix, Arizona) were placed on healthy skin on the upper back for 2 days, and

TABLE 1 Patch test reactions to 25 potentially relevant contact allergens of hair cosmetics

Hair cosmetic-associated allergens	Tested concentration vehicle (%)	No. tested	No. positive	%
Preservatives ^a		2842	414	14.6
Methylchloroisothiazolinone/Methylisothiazolinone	0.02 aq.	2840	330	11.6
Captan	0.5 pet.	125	3	2.4
Formaldehyde	2.0 aq.	2842	61	2.1
Formaldehyde releasers				
Diazolidinyl urea	2.0 pet.	1839	25	1.4
Quaternium-15	1.0 pet.	2841	35	1.2
Imidazolidinyl urea	2.0 pet.	2837	23	0.8
2-Bromo-2-nitropropane-1,3-diol	0.25 pet.	138	1	0.7
DMDM hydantoin	1.0 pet.	428	2	0.5
Zinc pyrithione	1.0 pet.	126	2	1.6
2-Chloroacetamide		361	4	1.1
4-Chloro-3-cresol	1.0 pet.	366	1	0.3
4-Chloro-3,5-xyleneol	0.5 pet.	369	0	0
Surfactants ^a		1439	112	7.8
Cocamidopropyl betaine	1.0 aq.	1437	104	7.2
Lauryl glucoside	3.0 pet.	362	12	3.3
Hair coloring agents ^a		2842	200	7.0
<i>p</i> -Aminophenol	1.0 pet.	144	24	16.7
Toluene-2,5-diamine	1.0 pet.	153	21	13.7
2-Nitro- <i>p</i> -phenylenediamine	1.0 pet.	149	15	10.1
<i>m</i> -Aminophenol	1.0 pet.	143	12	8.4
<i>p</i> -Phenylenediamine	1.0 pet.	2842	182	6.4
Ammonium persulfate	2.5 aq.	141	8	5.7
Hydroquinone	1.0 pet.	530	13	2.5
Hydrogen peroxide	3.0 aq.	135	1	0.7
Resorcinol	1.0 pet.	417	2	0.5
Perm compounds ^a		137	2	1.5
Ammonium thioglycolate	2.5 aq.	137	1	0.7
Glyceryl thioglycolate	1.0 pet.	136	1	0.7

^aPositive rate in groups of allergens was calculated from reactivity to at least one allergen in each group.

reactions were read on day (D) 2, D4, and/or D7, in compliance with the guidelines of the International Contact Dermatitis Research Group.¹⁵

2.2 | Market survey

Most hair cosmetic products available for sale in the Thai market were collected. The ingredients were recorded from the labels on those products sold in markets, supermarkets, department stores, and upmarket and downmarket professional hair salons in order to reflect the actual exposure of Thai consumers and hairdressers. The ingredients listed on the labels of 782 products were entered into a Contact Allergen Avoidance Program database using Microsoft Access (Microsoft Corporation, Redmond, Washington).

2.3 | Statistical analysis

PASW Statistics for Windows, version 18 (SPSS, Chicago, Illinois) was used for statistical analysis. The demographic data were analyzed by comparing patients with positive and negative reactions to one or more of the 25 hair cosmetic allergens. The chi-square or Fisher exact test was used to evaluate differences in the proportions between the groups. The independent samples *t* test was used to compare the quantitative data between the groups. Logistic regressions were used for univariate and multivariate analyses, respectively, to identify the factors influencing contact allergy to the hair cosmetic allergens in the patients with positive and negative patch test reactions. A *P*-value of <0.05 was considered to be statistically significant.

3 | RESULTS

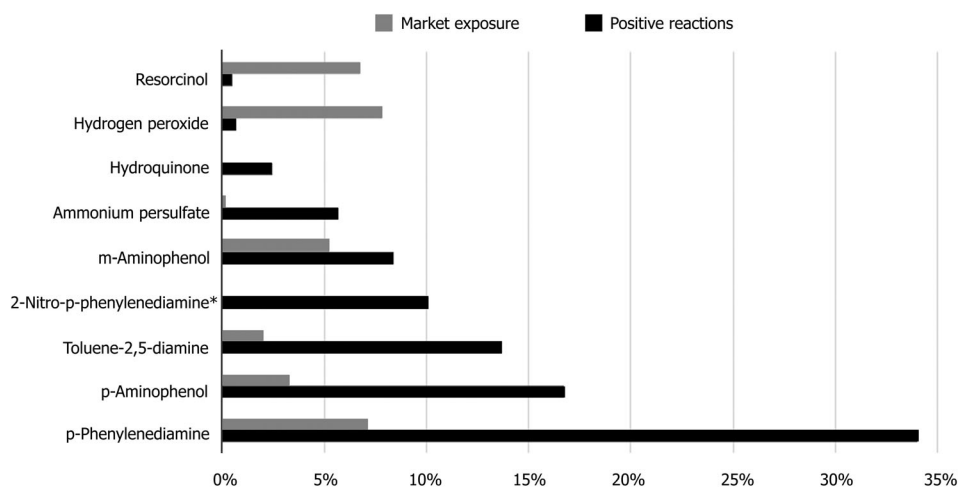
Contact allergens potentially relevant for hair cosmetic product allergy from baseline and hair dressing series are listed in Table 1. Of all four categories, preservative agents demonstrated the highest percentage (14.6%) of positive patch test reactions. Among the preservatives, methylchloroisothiazolinone/methylisothiazolinone (MCI/MI) had the highest allergy share (11.6%). Surfactants were the second most

frequently positive allergen category (7.8%), with cocamidopropyl betaine (CAPB) being the most common surfactant causing positive reactions (7.2%). Positive patch test reactions to the group of hair dye allergens were found in 7.0% of the patients overall. *p*-Aminophenol was the most common allergen in the group, followed by TDA and 2-nitro-*p*-phenylenediamine (2-NPPD). PPD was tested in 2842 patients as it had been in the baseline series and gave positive reactions in 6.4% of all patients. Concerning only those 153 patients who underwent patch test with hair dressing series, the share of positive reactions to PPD was 34.0%. The color couplers and oxidizing agents of hair dyes (including ammonium persulfate, hydroquinone, hydrogen peroxide, and resorcinol) displayed much lower prevalence rates than the primary intermediates. Perming compounds (ammonium thioglycolate and glyceryl thioglycolate) rarely caused sensitization. The correlation between the market exposure of the ingredients listed on the hair dye product labels and the patch test positivity indicative of exposure to the defined contact allergens in patients is illustrated in Figure 1.

Concerning patients with positive reactions, 663 of 2842 patients (23.3%) had positive reactions to one or more of the relevant allergens. The mean age ($\pm$ standard deviation) of the patients was 44.9 years ($\pm$ 14.1), and most patients (510; 76.9%) were female. Allergic rhinitis was found in 227 patients (34.3%), whereas 50 (7.6%), 49 (7.4%), and 41 (6.2%) patients had atopic dermatitis, allergic conjunctivitis, and asthma, respectively. A family history of atopy was reported by 229 (34.5%) patients, and a cosmetic allergy history was reported by 102 (15.4%) patients. There were 23 (0.8%) hairdressers. The most commonly affected site was the hands (47.7%), followed by generalized lesions (16.4%), the face (15.4%), and the head and neck (13.9%). A total of 524 patients (79.3%) had clinically relevant contact allergy and were diagnosed with ACD. Other diagnoses associated with the positive reaction group were atopic dermatitis (13.3%) and irritant contact dermatitis (10.0%).

A multivariate analysis was performed to identify the factors influencing contact allergy by comparing the results of the patients with positive and negative patch test reactions. The risk factors independently affecting hair cosmetic ACD were age, location of

FIGURE 1 Correlation between positive patch test reactions in patients who were patch tested with allergens in hair dressing series and market exposure to ingredients of hair dyes in the Thai market. *2-Nitro-*p*-phenylenediamine has been banned from the Thai market since 2013



dermatitis, and definite diagnosis. The patients with positive reactions to hair cosmetic ingredients were significantly older than those with negative patch tests ($P = 0.001$). There was no statistically significant difference between males and females. The significant predominantly affected sites of the patients with positive reactions were the hands (adjusted odds ratio [95% confidence interval], 1.52 [1.12–2.06]), and the head and neck (1.55 [1.25–1.93]). A personal or family history of atopic diathesis was not significantly different between the two groups. In addition, occupation was not significantly associated with hair cosmetic ACD ($P = 0.19$).

Regarding PPD allergy, a cross-reaction or concomitant sensitization to PPD with other hair dye allergens was identified in 182 patients who had a positive reaction to PPD (Table 2). *p*-Aminophenol showed the highest concomitant proportion of 44.9%, followed by TDA (36.5%) and 2-NPPD (26.9%).

4 | DISCUSSION

According to the allergen categories, preservatives had the highest share of positive reactions, followed by surfactants. Preservatives are widely used in almost all consumer products, including hair cosmetics, and therefore exposure is ubiquitous. Moreover, in this group in the current study, MCI/MI was found to be the most common preservative to cause positive reactions. This might be because the patients were generally sensitized to MCI/MI from not only hair cosmetics, but also other kinds of leave-on and rinse-off products. Isothiazolinone exposure and contact allergies have also been recognized as a global epidemic, including in Thailand.¹⁶ Surfactants were the second most common category of contact allergens in this study, mainly due to CAPB. The prevalence of contact sensitization from CAPB in this study was greater than that in previous reports from the United States and European countries,^{17,18} but similar to that found by a study in China.¹⁹ CAPB is a common ingredient in cosmetics and personal hygiene products (eg, shampoos, contact lens solutions, toothpaste detergents, makeup removers, bath gels, skin care products, cleansers, liquid soaps, antiseptics, and gynecological and anal hygiene products). CAPB is more frequently found in those products than lauryl glucoside, another substance having surfactant properties that also has allergenic potential.²⁰ Thus, CAPB was announced as “contact allergen

of the year” in 2004 due to its high sensitization prevalence.²¹ The high prevalence of positive patch test reactions to preservatives and surfactants in this study was probably due to the patients being also sensitized by a plethora of products other than hair cosmetics.

Hair dyes remained the most important sensitizers among exposed patients.¹² However, hair dye allergen was responsible for only 7.0% of the positive patch tests in our patients. The primary intermediates of oxidative hair dyes, *p*-aminophenol, TDA, 2-NPPD, *m*-aminophenol, and PPD, were frequent causes of contact allergy. Although these primary intermediates have been demonstrated to be strong skin sensitizers, PPD has attracted the most attention.⁴ The overall PPD contact allergy frequency was 6.4%, which was similar to reports from Europe where around 4% to 7% of patients had positive reactions.^{22–24} Of the 153 patients who underwent patch tests with the hair dressing series in this study, PPD remained the most frequent contact allergen among the primary intermediates. The high prevalence of PPD allergy may result from concomitant sensitization or cross-reaction to PPD with other hair dye allergens. In 2013, 2-NPPD was banned from hair coloring products sold in Thailand.⁸ Consequently, its sensitization prevalence has decreased from 53.8% between 2004 and 2008 (as reported by Boonchai et al)²⁵ to 10.1% in this present study.

Concerning the patients who were patch tested with additional hair dressing series, increasing consumer exposure to hair dye ingredients in the Thai marketplace might not be correlated with a rising prevalence of positive patch test reactions (Figure 1). PPD, *p*-aminophenol, and TDA were the primary intermediates of the currently available oxidizing hair dyes that showed high rates of patch test positivity in exposed individuals. This suggests that these agents are common contact sensitizers and need to be monitored closely. The Thai Food and Drug Administration has updated the legislation controlling the concentration of these chemicals in consumer products. Despite resorcinol being the hair dye ingredient that is most commonly found in permanent hair dye products,⁸ its sensitization prevalence was only 0.5%. It may be a less potent skin sensitizer than other hair dye substances in this study. Substances that frequently produce positive patch test reactions yet have a low exposure share are said to have a high sensitization capacity.⁴ Conversely, substances that infrequently produce positive patch test reactions but have high exposure shares are said to have a low sensitization capacity.⁴ Thus, the sensitization capacities of hair dye ingredients from high to low are PPD, TDA, *p*-aminophenol, *m*-aminophenol, and finally resorcinol.

Concomitant reactions among hair dye substances observed in this study could be explained by true cross-reactivity. However, it is challenging to distinguish cross-reactivity from co-sensitization. Co-sensitization has been described as a sensitization to two or more molecularly unrelated structures appearing concomitantly. Individuals sensitized to PPD may have cross-reaction with similarly structured hair dyes, such as TDA, 2-NPPD, or *p*-aminophenol.^{26,27} However, previous co-exposure and independent sensitization to both substances could not be ruled out because concomitant reactions to *m*-aminophenol and hydroquinone were also identified.¹⁰ Moreover, the effects of sensitization with combinations of allergens in hair dyes

TABLE 2 Concomitant sensitization to *p*-phenylenediamine with other hair dye allergens

Allergens	No. tested ^a	No. positive patch test (%)
<i>p</i> -Aminophenol	49	22 (44.9)
Toluene-2,5-diamine	52	19 (36.5)
2-Nitro- <i>p</i> -phenylenediamine	52	14 (26.9)
<i>m</i> -Aminophenol	48	12 (25.0)
Hydroquinone	60	3 (5.0)

^aA total of 182 patients who had positive reactions to *p*-phenylenediamine were analyzed.

should be considered.²⁸ There was some evidence that allergic responses in patients might increase after exposure to combined allergens in hair dyes compared with single exposure to allergens.²⁸

Ammonium persulfate, an oxidizing agent, was one of the main sensitizers in hair dye products, with a 5.7% share of positive reactions. This compound has been identified as an occupational contact allergen in hairdressers (18.7%), and it has been less frequently reported in consumers (2.1%).¹² Although our recent market survey revealed that less than 0.1% of products contained ammonium persulfate, about 5% of the patients in this study reacted to the allergen (Figure 1). The reactions could be due to previous sensitization because ammonia-free hair coloring products have become increasingly popular among consumers. Hydrogen peroxide has rarely been reported as a sensitizer,²⁹ which is consistent with our findings. Interestingly, the perm compounds ammonium thioglycolate and glyceryl thioglycolate caused a positive reaction in only one patient in this study. This finding was in line with a previous report.¹² The maximum concentration of glyceryl thioglycolate in hair care products has also been restricted by the Thai regulatory authorities. Thus, the use of perming products is considered safe.

Patients with ACD to hair cosmetic ingredients were significantly older, but the rates for both sexes were similar. This suggests that hair cosmetics were widely used by both males and females, and that patients could be equally sensitized. The ACD lesions were typically on the head, neck, and hands, corresponding to the sites of exposure. Despite these exposures to hair cosmetic allergens, only 10% of patients were diagnosed with irritant contact dermatitis. As far as we know, hairdressers wash their hands more frequently than consumers. Because the patients in this study were mostly not hairdressers, the hands might be less likely to show signs of irritant contact dermatitis.

In conclusion, preservatives and surfactants were the two most important contact allergens in hair cosmetics that were surveyed. Hair dye substances were also important contact allergens, and they might have cross-reactivity and co-sensitization between their ingredients. Perming agents were less likely to be the cause of allergic reactions. Hair cosmetics ingredients may change over time due to regional regulation. Continuous monitoring of the prevalence of contact allergens is needed to support optimal patient care.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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