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Review

Contact Dermatitis Due to Hair Care Products: A Comprehensive Review

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Abstract: Hair cosmetics are in fashion. Numerous products are commonly used in combination. Frequent allergens are present in hair cosmetics, which, with almost daily use, increase the risk of sensitization. Familiarity with the clinical distribution of the eczematous rash is necessary to seriously consider patch testing. Not all the products on the market are haptens. It is necessary to know how to patch your own products. When avoidance of the allergen is not possible, new treatments are evaluated to combat allergic contact dermatitis, mainly of the occupational type. In this manuscript, a complete and practical review of the main allergens and contact sources of hair cosmetic origin has been carried out.

Keywords: hair cosmetics; hair care products; allergens; irritant contact dermatitis; allergic contact dermatitis; patch tests

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1. Introduction

Contact allergy should be considered when evaluating scalp diseases, mainly when attributed to the use of hair care products (HCP). Typical erythema, peripheral spread, pruritus, and clinical history are key for the differential diagnosis. Notably, allergens administered to the scalp frequently produce dermatitis in the eyelids, ears, and neck, given the scalp's notable resistance to contact dermatitis. Nevertheless, the scalp can manifest severe reactions when exposed to potent allergens like paraphenylenediamine (PPD). The primary culprits for contact allergy on the scalp encompass bleaches and dyes, shampoos and conditioners, perming and straightening products, as well as topical medications [1]. Vehicles and preservatives are other allergens in addition to active ingredients or drugs. The use of topical steroids and oral antihistamines usually resolves dermatitis rapidly, with systemic steroids being required only in severe cases. Patch tests based on available series combined with the ingredients of the suspected elicitors confirm the diagnosis and facilitate allergen avoidance and the selection of alternative products [2–4].

Although cosmetic and hair product safety has improved, increased hair care consumption and the consequent allergen exposure have raised patient safety concerns. Frequently encountered allergens, including PPD [5], preservatives, nickel, cobalt, balsam of Peru, fragrance mix [6], and carba mix, have been documented in scientific literature as contributors to the development of allergic contact dermatitis (ACD) of the scalp. Commercially available hair products often contain these allergens. The most common sources of allergens are hair dyes [7], shampoos [8], and conditioners, but wigs, headbands, hats, masks, and spectacles may also be allergenic [1]. Dermatitis confined solely to the scalp, without affecting the neck, face, or other body regions, is infrequent, making this subgroup of patients with isolated scalp symptoms intriguing. Predominant indicators encompass eczematous lesions, pruritus, and a sensation of burning on the scalp. Isolated scalp dermatitis, exclusive of involvement of the neck, face, or other body parts, is an uncommon presentation but

warrants special attention. Identifying this specific group of patients exhibiting distinctive symptoms, including eczematous lesions, itching, and a burning sensation, is crucial for healthcare professionals. This recognition enhances their capacity to deliver personalized patient education, counseling, and treatment [9,10].

This article explores the spectrum of allergens frequently causing scalp ACD, emphasizing the prevalence of common triggers. Despite improvements in cosmetics and hair product safety, the literature reports a continued association between these allergens and scalp dermatitis. The aim of this review is to provide clinicians with a thorough comprehension of contact dermatitis triggered by hair care products. This aims to enable prompt diagnosis, successful avoidance of allergens, and the informed selection of alternative products, ultimately contributing to improved patient care.

2. Clinical Patterns

Allergens able to cause allergic contact dermatitis are commonly present in hair cosmetics, including shampoos, hair dyes, bleaches, and straightening creams. This dermatological condition is notably prevalent among hairdressers, who encounter these products regularly and may develop dermatitis on their hands. In contrast, clients and individuals using these products at home are more prone to experiencing dermatitis on their head, neck, and face. Recognizing the potential risks associated with these products is crucial, and appropriate precautions should be taken to prevent allergic reactions. The robust barrier offered by the thick epidermis, the lack of creases and folds, and the numerous pilosebaceous glands contribute significantly to restricting the entry of allergens into the scalp [1,9–11].

- Washing patterns. Lesions are caused by the drainage of allergens from the lateral areas of the face (Figure 1). These situations often result from the use of shampoos, conditioners, or comparable products that are applied temporarily to the scalp and have brief but repeated contact with the facial skin [1].

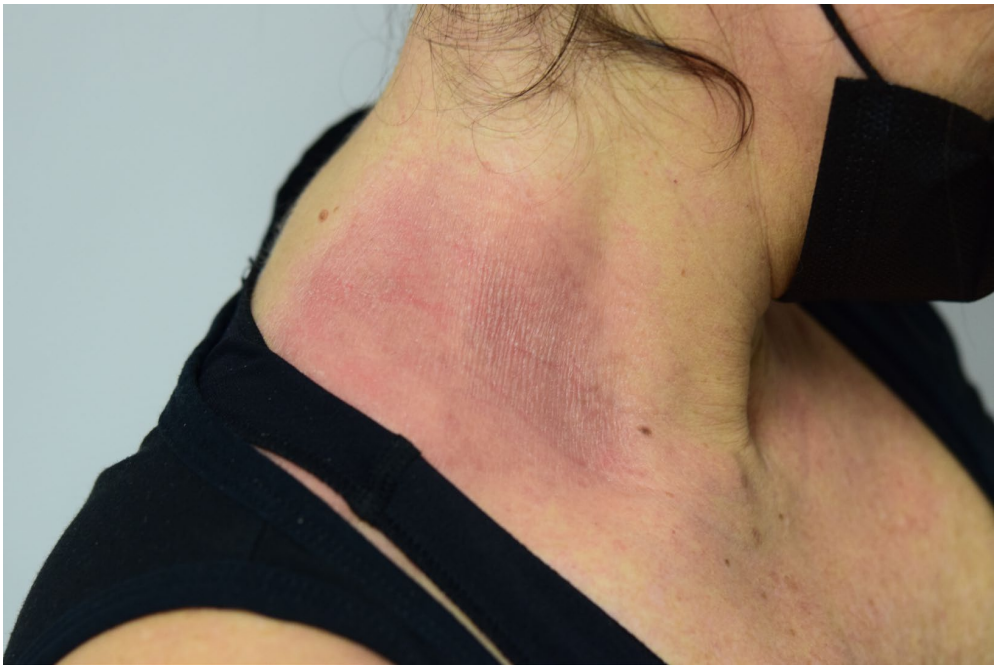


Figure 1. Laterocervical eczematous eruption. Positive patch test at 96 h to methylisothiazolinone. Present relevance was established for a component of shampoo.

- Hairline pattern. Contact dermatitis displays a distinctive distribution along the hairline, characterized by eczema plaques at the junction of the hairline and the facial skin (Figure 2). Regions frequently impacted include the frontal area, retroauricular

region, nape, and the area above the ears. This pattern is often observed in cases linked to using hair dyes and perms [1].

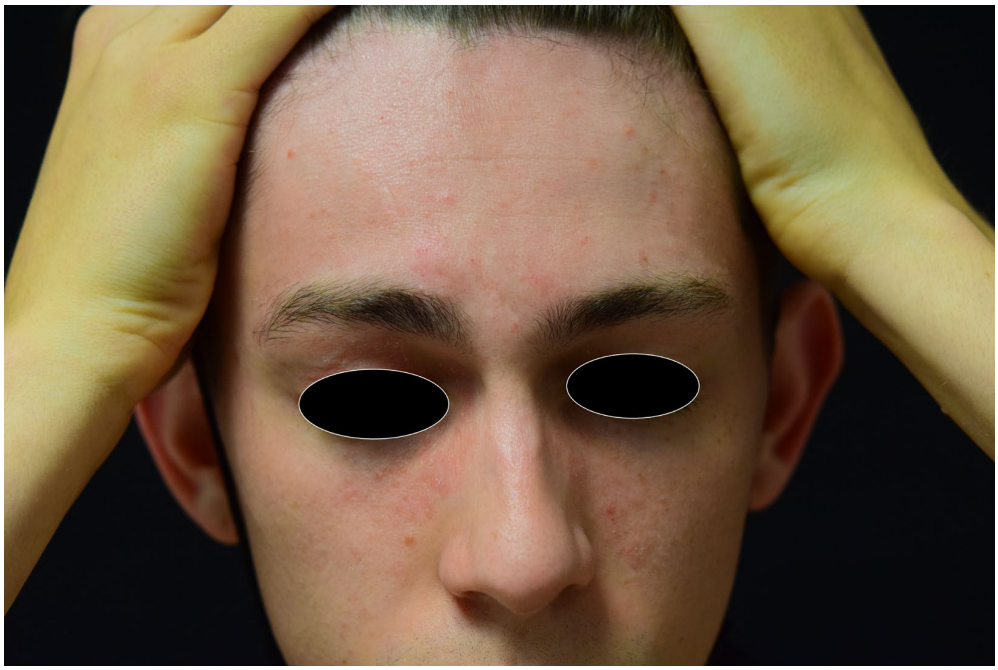


Figure 2. Localized dermatitis in the area of hair implantation and extension to the forehead and eyelids. The patch test was positive at 96 h for decyl glucoside. Present relevance was established for an ingredient in shampoo.

- Geographical pattern. The reaction often presents as eczematous plaques that delimit the area of contact with the allergen (Figure 3). This pattern is typical of allergic responses to objects such as hair bands/clips, wigs, hats, and masks [1].

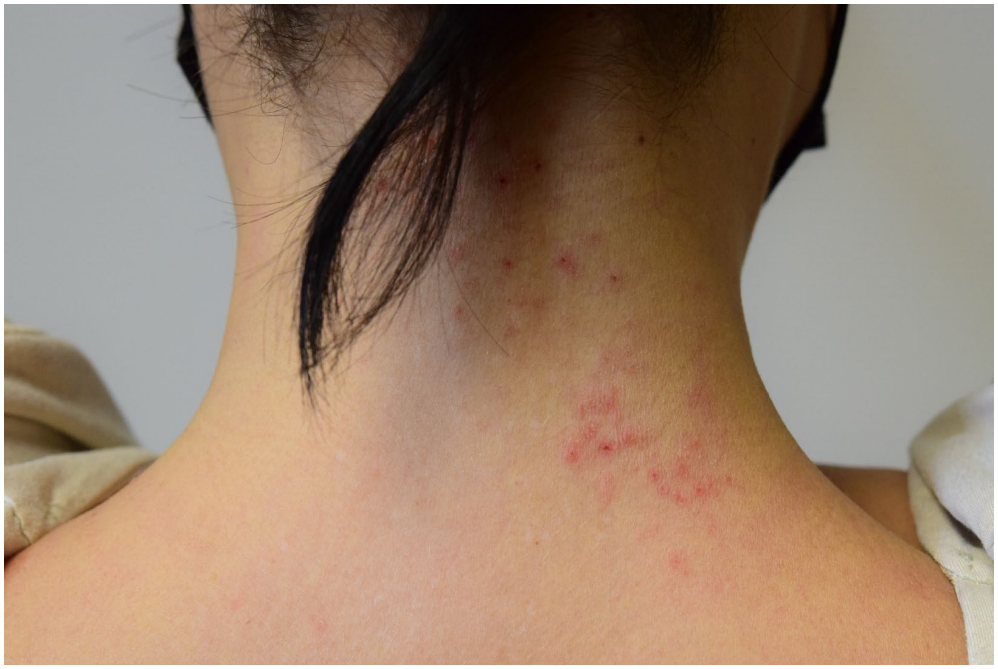


Figure 3. Eczematous plaque located in the occipital region. The patch test was positive for nickel sulfate. The use of a metal object with a positive dimethylglyoxime test confirmed the relevance.

3. Patch Test

The patch test is acknowledged as the gold standard for investigating allergic contact dermatitis. Concerning hair cosmetics, we already have relevant allergens such as paraphenylenediamine (PPD) and preservatives such as isothiazolinones in most working groups' basal batteries. However, hair products contain other molecules with sensitizing power grouped in a specific hairdressing battery. The first step will be to combine both batteries and, depending on the case, associate with others, such as the fragrance battery or gums. We must remember that testing one's products can be vital for confirming the diagnosis given that sometimes the culprit allergen is not marketed and can only be retrieved through the source of sensitization itself. Patch testing with patients' products should be performed carefully. Leave-on products should be applied in a well. In contrast, rinse-off products must be diluted, usually 10% in water vehicles, before being placed in the well. An alternative to this can be an application in semi-open or open without diluting. We must patch at least ten healthy controls to rule out the irritative reaction. The methodology used to perform the patch test correctly is included in the guide published in 2015 [12]. Occlusion of the allergens studied is recommended for 48 h, with a subsequent reading 15 min after lifting the occlusion dressing. The second reading takes place 96 h after the beginning of the study. In doubtful cases, a late reading can be performed after 7 or 10 days, especially for weak reactions after 96 h or when there is significant doubt about an irritative reaction.

Classic and emerging allergens are listed in Table 1, with the recommended concentration and vehicle for patch testing. Not all of them are commercialized, but they can be prepared on the workstation if necessary (Table 2).

Table 1. Allergens related to allergic contact dermatitis and hair cosmetics.

p-Phenylenediamine	1% pet.	Yes
Toluene-2,5-diamine	1% pet.	Yes
Toluene-2,5-diamine sulfate	1% pet.	Yes
Zinc pyrithione	1% pet.	Yes
Ammonium persulfate	2.5% pet	Yes
Ammonium thioglycolate	2.5% aq.	Yes
4-Aminoazobenzene	0.25% pet.	Yes
m-Aminophenol	1% pet.	Yes
p-Aminophenol	1% pet.	Yes
Ammonium thiolactate [13]	2.5% pet./aq.	Yes
Chloroacetamide	0.2% pet.	Yes
Cocamide DEA	0.5% pet.	Yes
Cocamidopropyl betaine	1% aq.	Yes
Decyl glucoside	5% pet.	Yes
3-(Dimethylamino)-1-propylamine	1% aq.	Yes
Disperse Orange 3	1% pet.	Yes
Ethanolamine (monoethanolamine) [14]	2% pet.	No
Glyceryl thioglycolate	1% pet.	Yes
Hydrogen peroxide [15]	3% aq.	No
Hydroquinone	1% pet.	Yes
Lauryl glucoside	3% pet.	Yes
1-Naphthol	1% pet.	No
2-Nitro-p-phenylenediamine [16]	1% pet.	No
Oleamidopropyl dimethylamine	0.1% aq.	Yes
Pyrocatechol	1% pet.	No
Pyrogallol	1% pet.	No
Resorcinol	1% pet.	Yes
2-methylresorcinol	1% pet.	Yes
Shellac	20% pet.	Yes
Benzyl salicylate	10% pet.	Yes

Table 1. *Cont.*

Fragrances mix I	8% pet	Yes
Fragrances mix II	14% pet.	Yes
Diazolidinyl urea	2% pet.	Yes
Imidazolidinyl urea	2% pet.	Yes
Formaldehyde	2% aq.	Yes
Nickel sulfate	5% pet.	Yes
Cobalt chloride	1% pet.	Yes
Panthenol	5% pet.	Yes
Peru Balsam	25% pet.	Yes
Methylisothiazolinone	0.2% aq.	Yes
Methylisothiazolinone/Methylchloroisothiazolinone	0.02% aq.	Yes
p-chloro-m-cresol	1% pet.	Yes
chloroxylenol	0.5% pet.	Yes
Cysteamine HCl	0.5% pet.	Yes
Hydroxyethyl-p-phenylenediamine sulfate	2% pet.	Yes
p-methylaminophenol	1% pet.	Yes
Cetrimonium bromide	0.5% pet.	Yes
Thioglycolic acid	8–11% pet.	No

Table 2. List of allergens, chemical structure and molecular formula. The appropriate percentage and vehicle to perform the patch test are included (marketed or non-marketed availability is provided depending on the allergen).

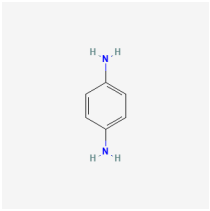
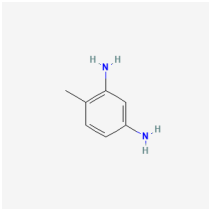
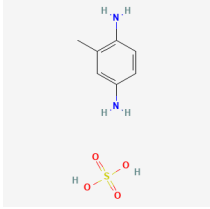
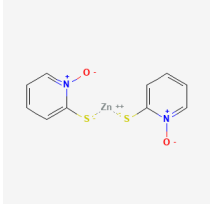
Allergen (INCI Name)	Chemical Structure		% Vehicle	Commercialized
	Chemical Structure	Molecular Formula		
p-Phenylenediamine		$C_6H_8N_2$	1% pet.	Yes
Toluene-2,5-diamine		$C_7H_{10}N_2$	1% pet.	Yes
Toluene-2,5-diamine sulfate		$C_7H_{12}N_2O_4S$	1% pet.	Yes
Zinc pyrithione		$C_{10}H_8N_2O_2S_2Zn$	1% pet.	Yes

Table 2. *Cont.*

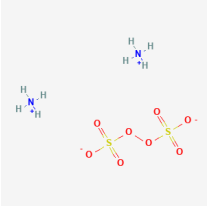
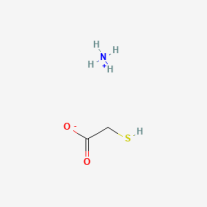
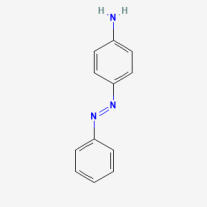
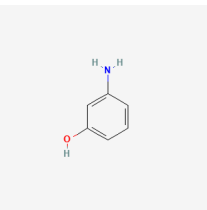
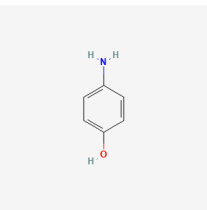
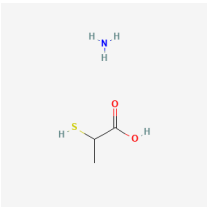
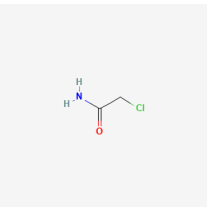
Allergen (INCI Name)	Chemical Structure		% Vehicle	Commercialized
	Chemical Structure	Molecular Formula		
Ammonium persulfate		$H_8N_2O_8S_2$	2.5% pet	Yes
Ammonium thioglycolate		$C_2H_7NO_2S$	2.5% aq.	Yes
4-Aminoazobenzene		$C_{12}H_{11}N_3$	0.25% pet.	Yes
m-Aminophenol		C_6H_7NO	1% pet.	Yes
p-Aminophenol		C_6H_7NO	1% pet.	Yes
Ammonium thiolactate		$C_3H_9NO_2S$	2.5% pet./aq.	Yes
Chloroacetamide		C_2H_4ClNO	0.2% pet.	Yes

Table 2. *Cont.*

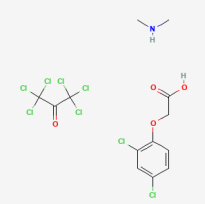
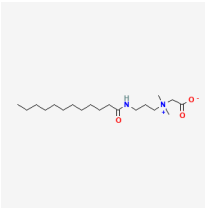
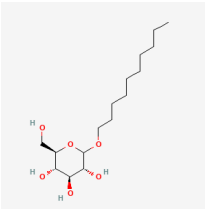
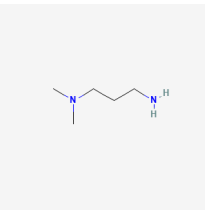
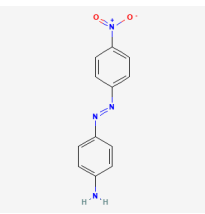
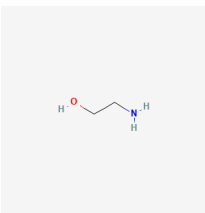
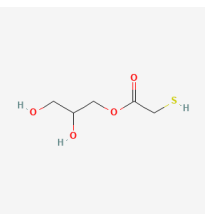
Allergen (INCI Name)	Chemical Structure		% Vehicle	Commercialized
	Chemical Structure	Molecular Formula		
Cocamide DEA		Not available	0.5% pet.	Yes
Cocamidopropyl betaine		$C_{19}H_{38}N_2O_3$	1% pet.	Yes
Decyl glucoside		$C_{16}H_{32}O_6$	5% pet.	Yes
3-(Dimethylamino)-1-propylamine		$C_5H_{14}N_2$	1% aq.	Yes
Disperse Orange 3		$C_{12}H_{10}N_4O_2$	1% pet.	Yes
Ethanolamine (monoethanolamine)		C_2H_7NO	2% pet.	No
Glyceryl thioglycolate		$C_5H_{10}O_4S$	1% pet.	Yes

Table 2. *Cont.*

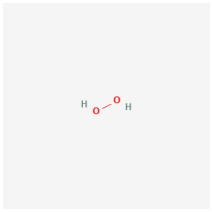
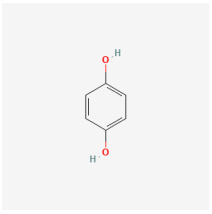
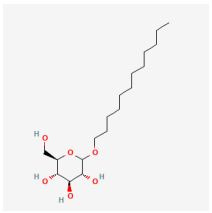
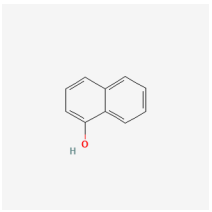
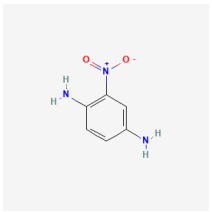
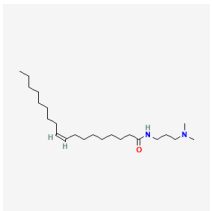
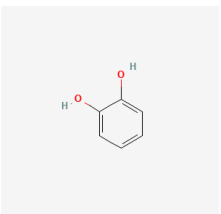
Allergen (INCI Name)	Chemical Structure		% Vehicle	Commercialized
	Chemical Structure	Molecular Formula		
Hydrogen peroxide		H_2O_2	3% aq.	No
Hydroquinone		$C_6H_6O_2$	1% pet.	Yes
Lauryl glucoside		$C_{18}H_{36}O_6$	3% pet.	Yes
1-Naphthol		$C_{10}H_8O$	1% pet.	No
2-Nitro-p-phenylenediamine		$C_6H_7N_3O_2$	1% pet.	No
Oleamidopropyl dimethylamine		$C_{23}H_{46}N_2O$	0.1% aq.	Yes
Pyrocatechol		$C_6H_6O_2$	1% pet.	No

Table 2. *Cont.*

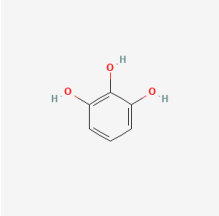
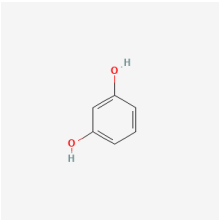
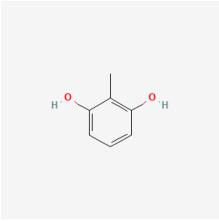
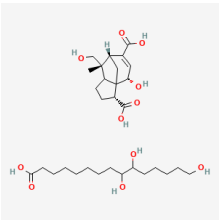
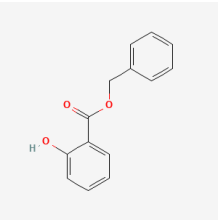
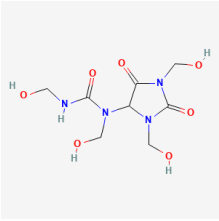
Allergen (INCI Name)	Chemical Structure		% Vehicle	Commercialized
	Chemical Structure	Molecular Formula		
Pyrogallol		$C_6H_6O_3$	1% pet.	No
Resorcinol		$C_6H_6O_2$	1% pet.	Yes
2-methylresorcinol		$C_7H_8O_2$	1% pet.	Yes
Shellac		$C_{30}H_{50}O_{11}$	20% pet.	Yes
Benzyl salicylate		$C_{14}H_{12}O_3$	10% pet.	Yes
Fragrances mix I	Not available	Not available	8% pet	Yes
Fragrances mix II	Not available	Not available	14% pet.	Yes
Diazolidinyl urea		$C_8H_{14}N_4O_7$	2% pet.	Yes

Table 2. *Cont.*

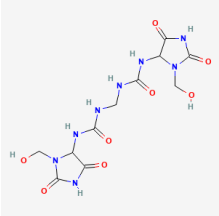
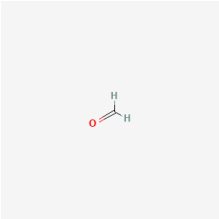
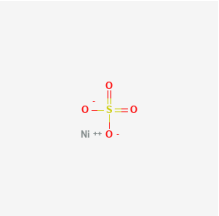
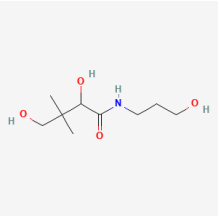
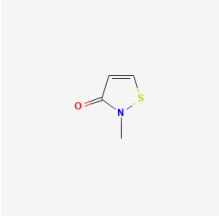
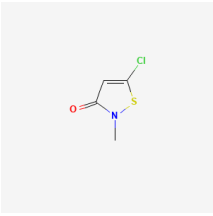
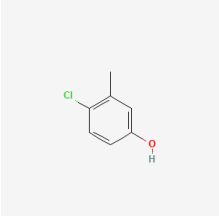
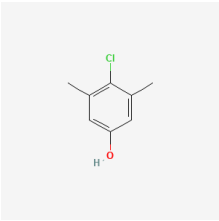
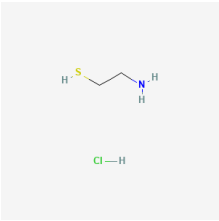
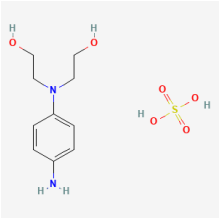
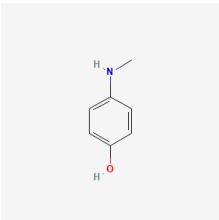
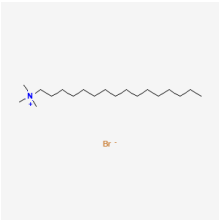
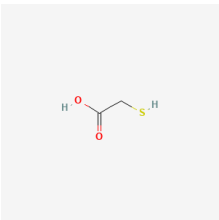
Allergen (INCI Name)	Chemical Structure		% Vehicle	Commercialized
	Chemical Structure	Molecular Formula		
Imidazolidinyl urea		$C_{11}H_{16}N_8O_8$	2% pet.	Yes
Formaldehyde		CH_2O	2% aq.	Yes
Nickel sulfate		NiO_4S	5% pet.	Yes
Cobalt chloride		Cl_2Co	1% pet.	Yes
Panthenol		$C_9H_{19}NO_4$	5% pet.	Yes
Peru Balsam	Not available	Not available	25% pet.	Yes
Methylisothiazolinone		C_4H_5NOS	0.2% aq.	Yes
Methylisothiazolinone/ Methylchloroisothiazolinone		C_4H_4ClNOS	0.02% aq.	Yes

Table 2. *Cont.*

Allergen (INCI Name)	Chemical Structure		% Vehicle	Commercialized
	Chemical Structure	Molecular Formula		
p-chloro-m-cresol		C_7H_7ClO	1% pet.	Yes
chloroxylenol		C_8H_9ClO	0.5% pet.	Yes
Cysteamine HCl		C_2H_8ClNS	0.5% pet.	Yes
Hydroxyethyl-p-phenylenediamine sulfate		$C_{10}H_{18}N_2O_6S$	2% pet.	Yes
p-methylaminophenol		C_7H_9NO	1% pet.	Yes
Cetrimonium bromide		$C_{19}H_{42}BrN$	0.5% pet.	Yes
Thioglycolic acid		$C_2H_4O_2S$	8–11% pet.	No

The dermoscopic patterns observable in patients with ACD located on the scalp have recently been published. Erythema and scales are present in all patients, while the vascular pattern is characterized by arboriform vessels and red loops [17].

4. Allergens

In cases of ACD affecting the scalp, dyes emerge as the most frequently cited culprits, followed by shampoos and conditioners. Within dyes, PPD stands out as the predominant allergen [18–21]. PPD, an oxidative dye found in numerous coloring products [18], exhibits its highest concentration in dark shades, although it is also present in brighter colors. Notably, some manufacturers may omit to declare its presence on product labels. The clinical manifestation specific to PPD-induced ACD is acute edematous dermatitis, predominantly affecting the eyelids, face, and neck, with minimal impact on the scalp [2,22].

Contrastingly, conditioners and shampoos are deemed unlikely instigators of ACD due to their brief contact duration and the rinsing-off process, rendering them well-tolerated even in sensitized individuals. Among the prevalent allergens in these hair care products (HCP) are fragrances, cocamidopropyl betaine, and preservatives such as quaternium-15 [6,10]. Lotions, including propylene glycol [23] as a vehicle and minoxidil, commonly harbor these key allergens. Clinical presentation requires differential diagnosis with seborrheic dermatitis or psoriasis as it consists of erythema, pruritus, scaling, and dryness of the scalp [1,3].

4.1. Surfactants

Surfactants serve as cleansing agents by disrupting the physicochemical bonds that bind impurities and residues to the hair [24]. Substances like non-soluble fats, such as sebum, do not dissolve easily in water. Upon encountering water, surfactants promote the formation of a micelle structure. The ionic ends of the surfactant are drawn to the surrounding water molecules, leading to the emulsification or suspension of particles in the water. In this emulsified state, these particles can be effectively rinsed off [25].

In cosmetic applications, formulations traditionally incorporate sodium dodecyl sulfate (SDS), valued for its effectiveness as a detergent and foaming agent. Nevertheless, considering its recognized irritant properties to the skin and mucous membranes, its utilization has diminished. Presently, formulations commonly opt for blends of surfactants possessing diverse properties, a strategic approach to optimizing performance while fostering ecological sustainability [10,26,27].

Classified according to the electric charge of their polar ends, surfactants are grouped into four categories: anionic, cationic, amphoteric, and nonionic. The primary cleaning agents fall under the anionic category. The key cleaning agents are predominantly found in the anionic category. Although anionic surfactants are efficient in eliminating sebum and dirt, their potent cleansing characteristics can heighten negative electrical charges on the hair's surface, leading to an escalation in frizz and friction [25,27–30]. Secondary surfactants are integrated into formulations to minimize potential harm and offset the repercussions of static electricity caused by anionic surfactants. These additional surfactants encompass cationic types, amphoteric surfactants, and nonionic surfactants. Cationic surfactants, possessing a positive charge, promptly adhere to negatively charged strands induced by anionic surfactants, effectively diminishing the frizz effect. We will delve into the specific types of surfactants within each classification [24,25].

- **Anionic surfactants**: Anionic surfactants such as sodium laureth sulfate (SLES), sodium lauroyl methyl isethionate (SLMI), or sodium methyl lauroyl taurate (SLMT) are often found in commercial shampoos [25].
- **Cationic surfactants**: Benzalkonium chloride, trimethylalkylammonium chloride, and cetrimonium chloride are cationic surfactants that are cosmetically acceptable for hair conditioning products. These surfactants, notably employed as hair softeners, contribute to effective conditioning [25].

- **Nonionic surfactants**: Nonionic surfactants, notably, ethoxylated surfactants based on ethylene oxides, represent the most prevalent type in this category. Another significant group of nonionic surfactants includes 'multihydroxy' compounds, such as glycol esters, glycerol and polyglycerol esters, glycosides, and polyglicosides, as well as sucrose esters. They are commonly used for mild cleansing purposes [25,30].
- **Amphoteric surfactants**. Predominantly represented by N-alkyl betaines derived from trimethylglycine (betaine), these surfactants find applications in mild cleansing formulations [25].

4.2. Preservatives

Preservatives are often used to avoid the biological degradation of cosmetics by the microorganisms that frequently contaminate them. However, the ideal preservative with excellent antimicrobial activity, stability, and effectiveness over a wide pH range, as well as nontoxic, nonirritant, and non-sensitizing properties has not yet been identified [31–34]. Preservatives are extensively used in a variety of consumer products, such as hair cosmetics, resulting in widespread exposure. Parabens [35] are the most utilized preservatives in cosmetic products, followed by formaldehyde releasers and isothiazolinones. The preservatives associated with the highest rates of sensitization include methyldibromoglutaronitrile, formaldehyde, and Kathon CG, while parabens exhibit the lowest prevalence [31,34].

Parabens: Parabens constitute a group of alkyl esters, including methyl-, ethyl-, propyl, butyl-, and benzyl paraben, derived from para-hydroxybenzoic acid. Renowned for their exceptional properties, they stand out as one of the most extensively utilized preservatives in cosmetic, pharmaceutical, and food products. In cosmetic formulations, parabens rank as the most prevalent preservative, with the Food and Drug Administration designating them as the second most common ingredient, surpassed only by water. When used as cosmetic preservatives on healthy skin, their sensitization capacity is relatively low, at approximately 1%, representing one of the lowest rates among preservatives. However, instances of sensitization are markedly higher when therapeutic preparations are applied to damaged skin [36–38].

Formaldehyde and formaldehyde releasers: Formaldehyde is an allergen that is widely present. Employed as a preservative in numerous cosmetic, household, and industrial items, formaldehyde also represents a contaminant in various products. In the European Union, the permissible maximum concentration of formaldehyde in cosmetics is 0.2% (0.1% in oral hygiene products), yet there is no explicit regulation regarding this in the United States [39,40]. Despite a reduction in the utilization of formaldehyde and its replacement with safer preservatives like formaldehyde releasers, leading to a decrease in sensitization occurrences, a recent upswing in cases has been identified. Formaldehyde releasers are substances that, when exposed to water, release formaldehyde in different quantities based on factors like the type of preservative, its concentration, and the water content in the product. While more than 40 substances of this kind have been identified, only a restricted number are utilized in dermatology units. Examples of formaldehyde releasers used in cosmetic products, listed in terms of formaldehyde release, include 2-bromo-2-nitropropane-1,3-diol (bronopol), imidazolidinyl urea (IU), dimethylol-dimethyl hydantoin (DMDMH), diazolidinyl urea (DU), and quaternium-15 [39,41–45].

Isothiazolinones: Isothiazolinones stand out as one of the most utilized preservatives and are present in approximately 23% of cosmetic products. Kathon CG is a mixture in a 3:1 ratio of methylchloroisothiazolinone (MCI) and methylisothiazolinone (MI) where MCI represents the more allergenic component. Alongside formaldehyde and quaternium-15, MCI/MI is a prevalent cause of allergic contact reactions with preservatives, with MCI/MI demonstrating the highest clinical significance among them [46–49]. Due to its sensitizing potential, the maximum permissible concentration of isothiazolinones in Europe has been regulated at 15 ppm for both rinse-off and leave-on cosmetics. There is a conjecture that the heightened use of methylisothiazolinone (MI) in isolation, without methylchloroisothiazolinone (MCI) as a preservative, has contributed to an increased sensitivity to MI.

Consequently, this has led to a rise in the prevalence of positive MCI/MI reactions through cross-reactions. If there is a suspicion of developing sensitivity to isothiazolinones, it is advised to conduct patch tests using both the MCI/MI mixture and MI alone. This is essential because patch testing with MCI/MI alone captures only around 40% of diagnosed MI allergies. The concentration of MI in the Kathon CG patch (25 ppm) is considerably lower than in the patch containing the isolated preservative (75 ppm) [46,48,49].

4.3. Fragrances

Considering the widespread inclusion of fragrances in various items, including shampoos, conditioners, and hair tonics, there is a substantial likelihood of the scalp being exposed to these fragrances. A minimum of 1% of the adult population is impacted by fragrance allergy. The aromatic sap known as balsam of Peru is obtained from the Myroxylon balsamum tree, native to Central and South America [50,51].

Balsam of Peru comprises numerous potential allergens, such as benzoic acid, benzyl acetate, benzyl benzoate, and cinnamic acid [52]. It is a naturally occurring, sweet-smelling substance frequently present in perfumes and fragrances. Patients should exercise caution when using products related to aromatherapy, scented oils, candles, air fresheners, deodorizers, or incense with scents like cinnamon, vanilla, or clove. Even products labeled as 'unscented' might contain a masking fragrance, so opting for truly unscented products is advisable [50,51,53,54]. Balsam of Peru is present in various products, including hair tonics, pomades, shampoos, conditioners, shaving lotions, aftershave perfumes, colognes, and scented cosmetics. Additionally, it is used in foods, beverages, and medicines, apart from its role in fragrances. Conducting patch tests for fragrance mix and balsam of Peru has the potential to detect up to 90% of cases involving fragrance allergies. Specifically, testing for balsam of Peru alone can identify 50% of these cases. Given the high probability of diagnosis, it is advisable to employ patch testing to identify fragrance allergies [50,51,53].

4.4. Conditioners

Conditioners serve to minimize friction, untangle hair, reduce frizz, and enhance combability. Their mechanism entails neutralizing the negative electrical charge present on the hair fiber by introducing positive charges, while concurrently lubricating the cuticle to reduce the hydrophilicity of the fiber [25]. These formulations include substances designed for antistatic and lubricating purposes, classified into five primary groups: polymers, oils, waxes, hydrolyzed amino acids, and cationic molecules. Notably, silicone emerges as the most active and widely employed conditioning agent. Cationic ingredients are frequently incorporated into various shampoo formulations alongside anionic surfactants to counteract charges and form a cationic–anionic complex, resulting in a neutral hydrophobic ingredient. Hair subjected to bleaching or chemical treatments demonstrates an increased affinity for conditioning agents due to its low isoelectric point (higher concentration of negative sites) and heightened porosity compared with untreated hair [25,55,56].

Protein hydrolysates (PHs) are incorporated into hair conditioners to mend damaged hair and impart a fuller appearance to the hair. Interestingly, instances have been documented where the inclusion of PHs in hair conditioners led to immediate skin reactions, such as urticaria, and, in some cases, more severe reactions like angioedema and bronchospasm [57].

4.5. Antidandruff

Zinc pyrithione, an ingredient commonly found in shampoos, has demonstrated both safety and efficacy in addressing dandruff and scalp psoriasis. Research indicates its potential to reduce cell turnover rates in hyperproliferative dermatoses like psoriasis. Additionally, the compound exhibits fungistatic and antimicrobial properties, although the precise mechanism of these actions remains uncertain. Notably, irritant or allergic responses may rarely contribute to psoriatic flares and köbnerization. Instances have been

documented where psoriasis exacerbation occurred due to the induction of ACD resulting from the use of antidandruff shampoos including zinc pyrithione [58].

4.6. Dyes

Although most documented cases of ACD linked to hair dyes are linked to PPD-phenylenediamine (PPD), there are few other compounds in hair dyes recognized for their strong sensitizing potential. PPD is used as a component in both permanent and semi-permanent hair dyes [18,40]. Although this component is employed as a coloring agent in various cosmetic products, the primary cause of sensitization to PPD arises from exposure to hair dyes. There is a notable correlation between PPD sensitivity and individuals in the hairdressing profession. Individuals sensitized to PPD who use permanent hair dye may experience severe reactions characterized by eyelid (Figure 4), ear, or full-face edema. PPD derivatives, including para-amino diphenylamine (PAD), o-nitro-p-phenylenediamine (ONPPD), and para-toluene diamine (PTD), are also common triggers of cutaneous allergy in hair dye formulations, and potential cross-reactions among them may contribute to sensitization. Hair dyes fall into categories like permanent, semi-permanent, and temporary. Due to the differences among these categories, interpreting the patch test results may be challenging. Additionally, it is also essential to contemplate the possibility of cross-sensitization to distinct azo dyes and para-amino compounds, as described in previous reports, or concurrent contact allergy [18,33,59].

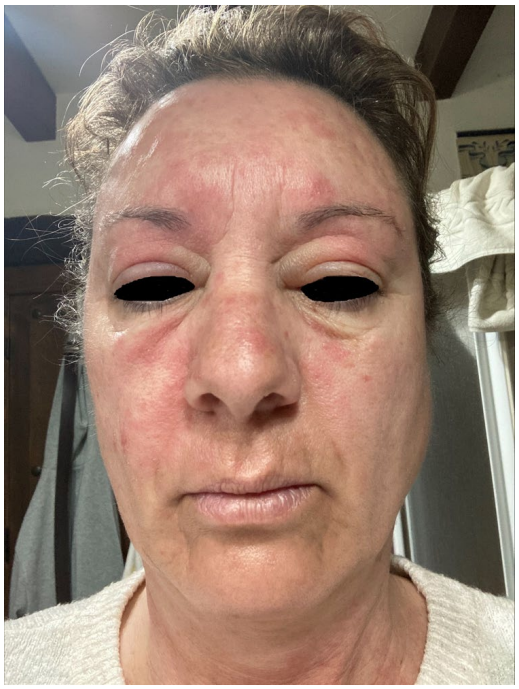


Figure 4. Facial eczematous rash with eyelid edema. The patch test was positive for PPD. Dermatitis was linked to the use of permanent hair dye.

Paradoxically, several studies suggest that the occurrence of allergic reactions to PPD appears to have decreased in recent years despite the worldwide increase in hair dye use. Also, there has been a decrease in the CAD incidence among hairdressing professionals, probably due to the use of gloves as protection. Nevertheless, the surge in body art trends, coupled with the utilization of temporary tattoos containing PPD dyes like black ink, seems to be a significant factor in initiating allergic contact reactions to hair dyes. The Cosmetic Ingredient Expert Panel has corroborated the safety of 2-amino-4-hydroxyethylaminoanisole and its sulfate derivative as coupling agents in oxidative hair dyes but warns against their use in other cosmetic products due to the potential formation of N-nitroso compounds.

Periodically, allergic contact dermatitis cases are documented for certain components of temporary dyes, including quinine [18,33,59].

Some researchers have investigated alternative hair dye options for hairdressers already sensitized to paraphenylenediamine. Hair dyes like Disperse Yellow 9, Disperse Red 11, and Disperse Blue 3 may be considered safer for patients with contact allergy to PPD. Other constituents present in hair dye formulations, such as resorcinol, m-aminophen, and 4-amino-2-hydroxytoluene, could potentially be responsible for allergic contact dermatitis. Additionally, scalp contact sensitization may also be induced by various ingredients in coloring products (persulphate salts), permanent products (thioglycolate of glycerine), preservatives, perfumes, shampoo/conditioning surfactants (CAPB, hydrolyzed animal proteins), or photoprotectants [18,40].

4.7. Anti-Hair Loss Products

Accessible in solution, gel, and foam formulations, topical minoxidil stands out as the most prescribed treatment for androgenetic alopecia. Approved for this indication, topical minoxidil is available in both 2% and 5% formulations [60]. Topical minoxidil proves to be a secure and efficient remedy for individuals with androgenetic alopecia. However, on occasion, it might cause itching, irritant dermatitis, or allergic contact dermatitis. Allergic contact dermatitis from topical minoxidil can present as pustular dermatosis on the scalp, eczematous lesions, erythema, itching, or scaling of the scalp [61]. The primary cause of allergic contact dermatitis following the use of topical minoxidil is often attributed to the solvents, namely, propylene glycol, butylene glycol, and glycerin, with minoxidil itself being an exceptionally rare culprit. In cases where allergic contact dermatitis is suspected, patch testing becomes imperative to discern whether the reaction is triggered by minoxidil or the solvents [62–66].

5. Pigmented Contact Dermatitis

Pigmented contact dermatitis is a rare form of ACD in patients with a high Fitzpatrick phototype (type V or VI). Certainly, this type of contact dermatitis tends to be underdiagnosed as its manifestations fall within the category of non-eczematous presentations. Scientific evidence exposes a more significant risk in patients who regularly use permanent hair dyes [67], particularly individuals with previous use of henna for hair coloring.

6. Antioxidants and Ecological Cosmetics

Technology and advances in cosmetics have led to the introduction of new molecules every year with specific properties that add value to the cosmetic product and improve hair conditions. Antioxidants are an increasingly used ingredient in shampoos, which usually eliminate surfactants like sodium lauryl sulfate to improve the quality of the product [68]. Antioxidants obtained from plants such as Hancornia speciosa [69], Cyclea peltata [70], or Withania frutescens [71] have been used with interesting benefits. Polyphenols are potent antioxidants that also behave as antibacterial and antifungal agents, making them an interesting molecule in this field.

This attractive field continues to develop, and new formulations appear every year. This entails a potentially serious problem in the field of contact dermatitis given that we still do not have allergens marketed for studying hypersensitivity reactions to these new haptens. Therefore, a definitive diagnosis of ACD cannot be reached in most cases.

7. Frontal Fibrosing Alopecia and ACD

In recent years, new hypotheses have been formulated trying to connect frontal fibrosing alopecia (FFA) with ACD. The reality is that the majority of FFA patients are women with a personal history of use/abuse of both facial and hair cosmetics. Dyes, hairsprays, and other hair cosmetics contain ingredients with a high sensitization potential. The most prominent allergens are ethylhexyl salicylate [72], drometrizole trisiloxane [73], diethylamino hydroxybenzoyl hexyl benzoate [74], and benzyl salicylate [75].

This topic is controversial. We have also found publications that have failed to establish a causal relationship between FFA and the use of shampoos [76] or even benzyl salicylate [77]. The debate can benefit from further research that will shed more light on the existing relationship between FFA and ACD.

These patients sometimes use hair prostheses that are usually fixed with adhesives containing acrylates [78]. Sensitization to acrylates has been reported due to the use of these wig fixatives in patients with FFA and, also, with alopecia areata [79].

8. Occupational Dermatosis: Hairdressing

Certainly, it stands out as one of the prevalent occupations encountered in contact dermatitis consultations. Exposure to the different allergens discussed throughout the manuscript is potentially relevant to hairdressing professionals [11]. PPD, nickel, isothiazolinones, fragrances, and formaldehyde/formaldehyde releasers are the most common haptens. Most of these allergens are encompassed in the standard panels adopted by nearly all contact dermatitis research teams.

A very interesting review of sensitization rates in hairdressers has recently been published [80]. PPD showed a high prevalence, reaching 4.3% of ACD cases. Other relevant haptens, such as toluene 2,5-diamine, ammonium persulfate, or glycerin thioglycolate, have global prevalence rates above 1.5%, which is why these allergens are included in the specific hairdressing battery.

It has been reported that these professionals have up to a fivefold increased risk of developing sensitization to haptens such as ammonium persulfate or glyceryl thioglycolate. Apart from skin manifestations, exposure to these allergens has also been linked to the onset of other conditions, like asthma or allergic rhinitis.

A relevant aspect that must always be considered is the false safety of some products labeled as hypoallergenic, especially when we talk about PPD. In a published study, it was observed that some of the "hypoallergenic" hair dyes contained PPD among their ingredients [81]. Educating the patient to avoid haptens is critical for therapeutic success in ACD, so teaching how to interpret product labeling is the foundation of any patch testing study.

Hairdressing is a business that has grown significantly and has incorporated aesthetic procedures involving acrylates and glue manipulation. This scenario must be considered given that these allergens must also be incorporated into the patch test in cases when the patient reports exposure to haptens such as 2-hydroxyethyl methacrylate and ethyl cyanoacrylate [82].

9. Treatment

Detection of the allergen or allergens responsible for the eczematous/non-eczematous rash is key to therapeutic success since their avoidance will lead to a complete or significant improvement in the skin lesions. Sometimes, patients show diseases overlapping with ACD, prompting the use of topical anti-inflammatory therapies such as corticosteroids or topical calcineurin inhibitors. Those situations that are not controlled by topical treatment may require systemic treatment with cyclosporine, methotrexate, or advanced therapies such as dupilumab [83]. Cases of scarring alopecia secondary to hair dyes have been reported [84]. Cases of telogen effluvium following scalp rash secondary to ACD have also been reported [85]. We must be cautious with the recommendation of hair restorers since cases of sensitization to glycyrrhizic acid [86] present in this type of product have been reported.

Figure 5 shows the most relevant allergens described whose source of contact is the hair cosmetic products marketed.

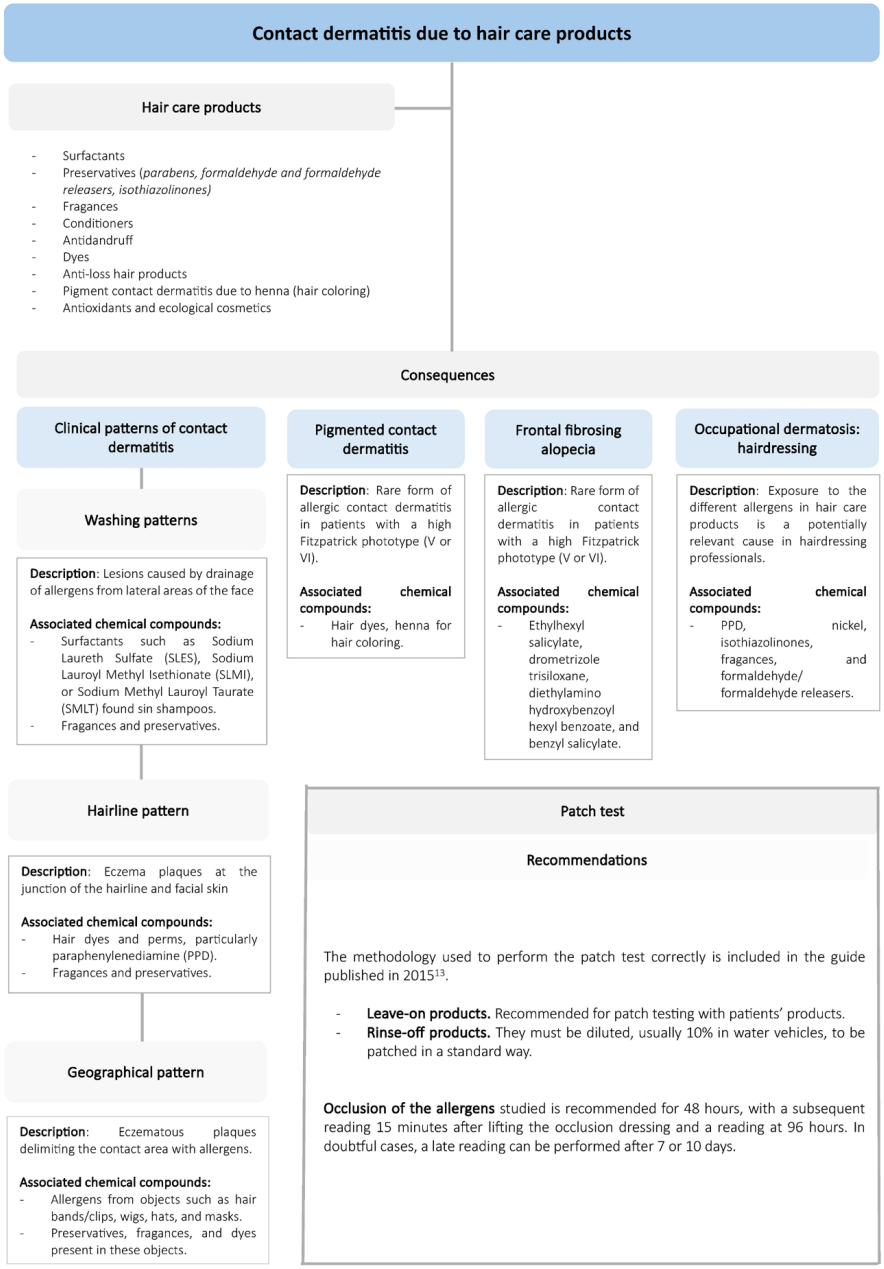


Figure 5. Visual scheme of consequences due to allergens in hair care products.

10. Conclusions

In conclusion, this comprehensive exploration of contact dermatitis induced by HCP underscores the evolving landscape of allergen exposure in cosmetic dermatology. The intricate patterns of scalp reactions, ranging from washing and hairline distribution to geographical manifestations, serve as valuable clinical indicators for healthcare professionals. Recognition of the diverse allergens, including prevalent culprits like paraphenylenediamine (PPD), fragrances, and surfactants, is crucial for timely diagnosis and targeted patient care.

Despite advancements in cosmetic safety, the persistence of common allergens in hair care products poses ongoing challenges, requiring vigilant awareness among healthcare providers and consumers.

As the dermatological community strives for enhanced patient safety, identifying emerging allergens and continuously refining diagnostic approaches, such as patch testing, remain imperative. Collaborative efforts between clinicians, researchers, and the cosmetics

industry are essential to advance our understanding of contact dermatitis, enabling the formulation of safer and more tolerable hair care products. By prioritizing informed allergen avoidance and promoting eco-friendly practices, we can contribute to a healthier and more sustainable future for dermatological care in hair cosmetics.

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