

Allergic Contact Dermatitis Due to Chemical Agents and Microbial Contamination in Cosmetic Products: A Review

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Abstract

Cosmetics are items that are used to enhance the appearance of skin complexion. Common cosmetics include lipstick, foundation, eyeliner, contour, skin primer, blushes, and other similar items. Cosmetics may cause allergies to the human body such as bronchial asthma, allergic rhinitis, allergic dermatitis, allergic conjunctivitis (eye inflammation), and anaphylaxis. Cosmetic allergies are becoming more common, owing to the preservatives and perfumes utilized in the goods. Microbial contamination, viz. bacteria (*Staphylococcus*, *Escherichia*, *Bacillus*, *Pseudomonas* etc.), molds and yeasts are also associated with cosmetics, resulting in allergic contact dermatitis (ACD). Patches and skin prick tests were used to quickly identify allergies. Once particular allergies have been discovered, patients should be educated about which drugs may be taken safely in the future. This review aims to provide cosmetology information to understand the causative agents, detection tests, and management to enhance the knowledge about ACD due to cosmetics.

Keywords: Cosmetics Microflora, Skin Allergens, Patch Testing, Prick Testing

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INTRODUCTION

Skin is the protective layer as well as a sensing structure for our body; and is the largest organ in the body. So, every skin cell may react to stress differently throughout time and behave differently than its surroundings, resulting in tissue that is extraordinarily varied. It also has a strict sleep cycle, and its actions change during the day and night. To maintain a balanced state, the skin generates bio-active molecules such as peptides and even certain lipids with antimicrobial activities that are aimed at managing the local bacterial population. Germs on the skin's surface have long been investigated and controlled using various cleaning treatments, with many dermatologists recommending the use of herbal and plant-based cosmetics to maintain a healthy skin condition. Allergic contact dermatitis (ACD) affects at least 10% of the total population, with hand dermatitis being the most common.¹

History of Cosmetics

Cosmetics were first discovered in Ancient Egypt around 4000 B.C., and Ancient Greeks, Romans, and Egyptians utilized cosmetics made of mercury, white lead, and frankincense. Cosmetics use throughout history has been indicative of a civilization's sensible issues, such as sun protection, a symbol of sophistication, or beauty conventions. Today's culture is obsessed with appearances, and there is an underlying assumption that before fashionable civilization, there was less pressure to change your appearance for the sake of beauty. When you examine the habits of people hundreds or thousands of years ago, you will notice that appearances have always been important to society. The history of makeup spans a minimum of measure at least 6000 years of human history.^{1, 2} Different body parts have different cosmetics products such as cosmetics for the skin, hair, eyes, nails and teeth. Skin cosmetics products include skin cream, compact powder, lipsticks, skin tonics, face packs, blushes, eye shadow, foundation, eyeliner, and lots of additional cosmetic products. On the other side, allergies to cosmetic products are increasingly observed. They are designed to be massaged, sprayed, powdered, showered on, or used on the body or any part of the body for cleansing,

beautification, or enhancement of appearance. Emulsification, mixing, compaction, moulding, and packaging are the most common techniques used in the cosmetics industry. Common materials employed in cosmetics products include; water, preservatives (parabens and formaldehyde-releasing preservatives), humectants (glycerin, propylene glycol, sorbitol), surfactants (stearic acid, atomic number 11 sodium lauriminodipropionate), oils, fats and waxes, artificial colors, perfumes and herbal materials.^{3,4}

Contamination of cosmetic products

In the course of people's day-to-day lives, makeup has a significant role in the transmission of infections. The majority of cosmetics, even those made to order, are rich in nutrients and water, making them excellent substrates for a number of microbes to survive. The quality of the cosmetics is reduced due to microbial contamination, which also has a negative impact on people's health. Despite the fact that contaminated cosmetic safety risks are relatively uncommon. The physiological and microbiological characteristics of the components and chemicals used in the product are types of microbial contamination that occur in cosmetics. Due to impurities in the raw materials, cosmetics may include microorganisms and become contaminated when used. In addition to changing the product's physical characteristics, such as colour, texture, aroma, and thickness, microbial decomposition can also make key ingredients inactive, depriving cosmetics of their desired effects. The skin may become irritated and react negatively to foreign particles and compounds produced by microbiological pollutants.⁵ Contaminants in custom designed cosmetics can come from a variety of sources, including contaminated raw materials, the personalized cosmetics' specific manufacturing process, proper sanitation in poor personal hygiene, as well as the workplace and equipment (e.g., inadequate shop air conditioning, reuse of kitchenware, etc.), the use of unsanitary raw materials as ingredients, even during manufacturing process, or during cosmetics use.^{4,6} Raw material testing, packaging material control, intermediate product control, shelf testing, and most importantly, a market survey are all examples of quality control tests

that are carried out.⁷ Quality control is basically a technique for keeping product quality at a desired level; it preserves a product's worth. It is a continuous procedure that analyses a cosmetic product to a standard to see whether it meets particular requirements or not. It includes information about production techniques, storage, filling, and packaging, as well as raw materials. Specification: Packaging material standards provide comprehensive information of qualities as well as permitted deviations: It includes all aspects of the product's shape, size, color, and other aesthetics, as well as acceptability standards and boundaries. Standard for the completed product: It contains all necessary features for optimum product performance, durability, and safety, as well as the testing procedure. Chemical and microbiological concerns were the two categories into which recalled cosmetic goods fell. The majority of recalls (87.35%) were caused by chemical hazards. The harmful *Pseudomonas aeruginosa* was the bacteria that were discovered the most frequently (35.48%). The following bacteria, yeast, and moulds were also discovered: *Burkholderia cepacia*, *Klebsiella oxytoca*, *Serratia marcescens*, *Enterobacter gergoviae*, *Enterobacter cloacae*, *Staphylococcus aureus*, *Achromabacter xylosoxidans*, *Rhizobium radiobacter*, *Candida albicans*, *Pantoea agglomerans*, *Citrobacter freundii*. Acne, chronic conditions hyperpigmentation, facial eczema, eyelid dermatitis, and cheilitis are some of the frequent cosmetic issues.^{6,7,8}

Allergic Contact Dermatitis

Allergic contact dermatitis (ACD) is described as an inflammatory infection that impacts the skin triggered by several chemical, physical, and biological factors in the environment.⁹ This results in skin, mucous and semi-mucous lesions caused by allergic and irritating pathogenic mechanisms. Between July 2013 and December 2014, the study conducted on patients visited the Clinical Division of the National JALMA Institute of Leprosy and other bacterial diseases in Agra, Uttar Pradesh, India. Cosmetic dermatitis was suspected in 400 patients based on clinical evidence, with an 18.60 percent relative prevalence, of the 2150 patients who attended contact dermatitis clinic over 18 months. Products involved in the positive

patch test identification are facial cream, soap/shampoo/face-wash, eye cosmetic/kajal, lipstick, etc.¹⁰

Cosmetic-induced allergic dermatitis is a typical dermatological complaint that has a substantial impact on the patient's quality of life. Skin hygiene and moisturizing products are the most common causes followed by cosmetic hair and nail product.^{11,2} ACD can spread symmetrically to different parts of the body that aren't exposed directly with the allergen; this is similar to a reaction caused by systemic exposure in which the allergen enter systemic contact-type dermatitis caused by cosmetics and affects the blood supply; nevertheless, systemic contact-type dermatitis is uncommon with cosmetics. Apart from delayed allergic reactions like contact dermatitis, acute reactions like contact urticaria (syndrome) can also occur on rare instances.^{5,9,12} The incidence of ACD to cosmetics in patients submitted for patch testing has been reported to range from 2 to 4 percent in the past, while more recent research show that these figures are steadily rising.^{8,13} Kathon CG (blend of methylchloroisothiazolinone and methylisothiazolinone), fragrances, and paraphenylenediamine were the most common causes of ACD to cosmetics during both study periods, and acrylates and sunscreens were identified as emerging allergens during the second period.^{6,9,14}

Chemical agents causing ACD

The chemical agents due to which ACD occurs are Poison ivy (present mostly in body lotion). It is a common cause of ACD which is an itchy skin rash.¹⁵ T-cells in the immune system identify a chemical foreign substance, which triggers an allergic reaction. However, T cells do not detect tiny molecules directly and these substances must undergo a chemical interaction with bigger proteins to become visible to T cells, membrane proteins that evoke an immune response within the body by binding to enzymes and pharmaceutical products. Formaldehyde is a frequent carcinogen (a substance that causes cancer).^{5,10,16} It is widely found in cleansers, hair spray, lashes adhesive, hair straightening treatments, liquid newborn washes, as well as other cosmetic and personal care goods that come into contact with skin and have the ability

to enter mucous membranes. Preservatives (Triclosan, Iodopropynyl butylcarbamate, etc.) and formaldehyde have been related to cancer and adverse skin responses.^{7,17} The study with a total of 20107 patch-tested participants from the general population exhibited the prevalence of contact allergy in 20.1 percent participants. It was concluded that at least 20 percent of the general population is contact-allergic to commonly experienced allergens,^{2,3} between July 2013 and December 2014, the study conducted on patients visited the Clinical Division of the National JALMA Institute of Leprosy and other bacterial diseases in Agra, Uttar Pradesh, India.¹⁸

Nickel is also a causative agent of ACD sometimes and the skin adversely reacts to nickel. The immune system incorrectly classifies the nickel ions that have entered the body as harmful and symptoms, in most cases, occur within 12 to 72 h. Nickel is often included in cosmetics such as mascara and eye shadows may induce ACD. Nickel was the most frequently tested allergen by the NACDG (North American Contact Dermatitis Group), with 20.1 percent of patch test clinic patients reacting to it.^{5,19} It is the most common allergy in patch test centers around the world.¹⁹ Neomycin frequently causes allergic reactions to skin resulted in red skin, scaly, and itchy, and it might impair your kidneys, especially if someone take certain antibiotics or cancer medications.²⁰ Parabens, a type of preservative, are found in a wide range of personal care, cosmetic, pharmaceutical and food items. They may be found in a variety of items, including soaps, lotions and cosmetics. According to study, they stimulate estrogen production and, interfere with brain activities and reproduction process. It permeates your skin and imitates estrogen, producing increased cellular growth in the breast, according to some studies this eventually leads to breast cancer.^{10,11,21}

Petroleum or coal tar is used to make synthetic colors. Coal tar is a viscous, thick, black liquid with a distinct odour.²² Many commercially marketed eye shadows include this ingredient. Synthetic colors can irritate the skin, create acne problems and may cause cancer. Perfumes, moisturizers, shampoo, cleansers, and conditioners all are kinds of skincare products containing fragrances. They are formulated with chemicals

(p-phenylenediamine, Coal-tar) that were linked to breathing issues, skin allergies, dermatitis, and reproductive system side effects.^{19,21,23} It has the potential to acts as carcinogen (cancer-causing agents), irritant, and endocrine disruptor.²⁴ Sunscreens contain chemicals such as PABA (Para-aminobenzoic acid), benzophenone, oxybenzone, Octyl methoxycinnamate, and homosalate. They are believed to absorb light, but instead serve as endocrine disruptors,²⁴ causing more problems i.e. Endocrine disruptors chemicals are linked to male and female reproductive health, kidney disease, overweight, metabolic disturbances, endocrine immune function, and a higher risk of hormone-sensitive tumours into the body. Endocrine irritants are included in sunscreen chemicals. In cosmetology, hydroquinone is a skin-lightening agent. Breakouts, pimples, inflammatory acne, age spots, and post-inflammatory hyperpigmentation can all cause pigmentation. Hydroquinone works by reducing the number of cells in the skin that produce melanin (melanocytes). On the other hand, hydroquinone is a known carcinogen^{16,25} Long-term usage can cause skin whitening by lowering the number of melanocytes in the body so it causes eye bags, hyper pigmentation, affects in tone and texture of the skin, and therefore can lead to skin cancer.²⁶

ACD Due to microbial contamination

The skin microbe plays a critical role in skin homeostasis. However, more research is required to acquire a full view of the natural skin microbiota composition and microbes, in addition to their complex interactions with the skin. Skincare sectors that have highlighted *S. Epidermidis*, as well as *C. Acnes* researchers are attempting to better understand the interaction of these two bacteria, which are constantly interacting with the skin system and its micro-environment. Beauty industries develop or market and sell active ingredients that maintain or restore a specific skin microbes following external stress or skin modification.^{15,18,27}

Staphylococcus aureus, *Escherichia coli*, *Bacillus cereus* and *Pseudomonas aeruginosa* as well as other mould (*Aspergillus*, *Cladosporium*, and *Stachybotrys Atra*) and yeasts (*Saccharomyces cerevisiae*, *Malassezia folliculitis*) have been found in cosmetics in several studies²⁸ however,

some bacteria and molds that cause human infections, such as *Staphylococcus epidermidis*, *Bacillus cereus*, *Bacillus circulans*, and *Aspergillus Versicolor*, have also been found.^{6,8} Fungus and yeast were found in 19.2 percent of cosmetics now in use. In comparison to bacteria, the fungal contamination ratio in cosmetics was modest.^{19,29} Involvement of microbes in ACD is also being observed, mostly *Streptococcus* or *Staphylococcus*. Patients are highly susceptible to certain cutaneous bacterial, fungal, and viral infections.³⁰ A variety of *S. aureus* and albus strains, as well as *Pfeiffer bacillus*, *E. coli*, *B. typhous*, and *B. paratyphoid* A and B were tested. The same type of reaction occurs in some individuals with derivations of some strains of these organisms; however, some of these filtrates caused reactions that showed up to be due to primarily toxic substances, also including acquired reactions to substances inactive in non-allergic individuals, as in the case of *Streptococcus* antigens. *B. coagulans* may help to prevent skin ageing by enhancing free radical scavengers. The microorganisms *S. hominis* and *Staphylococcus epidermidis* appear to prevent the growth of the bacteria that cause ACD symptoms.^{20,22,31}

Tests involved in detection of ACD

Various tests are carried out to recognize allergic contact dermatitis and define the severe allergic reaction in humans so that it can be allowed to treat and healed.

Patch Test It consists of a conformation test that can quickly identify the area of allergy and the type of allergy; it is the most basic method for investigating an adverse reaction area. Methodology of patch test includes applying a little



Figure 2. Showing Prick Test for Allergy³⁵ detection (Image by- The Zestfull Corp 2021)

quantity of allergen to the skin and covering it for approximately 48 h to identify delayed allergic responses. After that, the doctor will examine the skin for symptoms of an allergic response, such as redness, rashes, or hives, after 72 to 96 h. The doctor can then assess if the patient has had an allergic response based on the symptoms and indications. This is the most often performed test, because contact dermatitis accounts for 20 percent of all occurrences of dermatitis detected in children.^{31,32} After testing the interpretation of reaction are graded for each allergen on a spectrum such as negative, irritant, +/- doubtful, + weak positive, ++ moderate, +++ strong reaction as shown in Figure 1.³³



Figure 1. Showing Patch test³³ (Image by- The Australasian College of Dermatologists 2017)

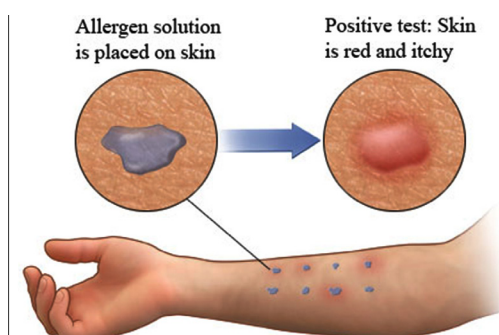


Figure 3. Showing Allergy Blood Test³⁹ (Signature Medical Group 2022)

Table. Alternatives used in cosmetics that maintain the skin without any harmful effects

Scientific name	Common name	Part used in cosmetics	Uses
<i>Avena sativa</i>	Oat	Fruit	Moisturizer, Skin tonic
<i>Aloe vera</i>	Aloe vera	Leaf	Moisturizer, Sunscreen, Emollient
<i>Calendula officinalis</i>	Marigold	Flower	The skincare, Anti-inflammatory, Antiseptic Creams
<i>Acorus calamus</i>	Sweet flag	Rhizome	Beauty Powders, Skin lotions
<i>Bauhinia racemosa</i>	Kanchivala or Bidi leaf tree	Leaves, Bark	Skin disorders
<i>Emblica Officinalis</i>	Amla	Fruit	Hair care products

Prick test

This skin prick test, often known as a punctured or scratch test, detects and reports allergic responses to 50 distinct compounds at the same time. It is commonly used to diagnose pollen, molds, pet, dust mite, and food allergies. The test is performed on the forearm in adults and the upper back in babies. They employ needles (lancets) that barely pierce the skin's surface, resulting in no bleeding.³⁴ Whenever the contaminant is incorporated beneath the layers of the skin in an allergy prick test as shown in Figure 2,³⁵ your immune response goes into overdrive. It specific antigens to defend itself against something that it perceives to be a dangerous chemical. When an infectious agent binds to a single category of immunoglobulin, toxins such as histamine are released.³⁶

Intradermal test

Clearly related to a skin prick test; however, allergens are injected into the top layer of the skin, and the results are evaluated for any indicators of an allergic reaction, such as redness, swelling, itching, and so on.³⁷

Allergy blood test performed with mixing patient's blood sample with an allergen to determine if antibodies are produced. If the patient develops antibodies in response to the allergen, then the patient will be most likely allergic to that allergen.³⁸ Immunoassay tests, such as the Enzyme-linked immunosorbent assay (ELISA, or EIA) and the Radioallergosorbent test are examples of allergy blood tests (RAST). Methodology used in allergy blood test specifies to firstly clean the test area (usually on the back or arm) with alcohol and afterwards place the allergen solution on the skin as shown in

Figure 3³⁹ and check the skin after 15 minutes for red, raised itchy areas called wheals; if a wheal forms, it means the skin is allergic to that allergen.⁴⁰

Alternatives of chemical ingredients used in cosmetics

A huge proportion of cosmetic formulations based on Indian herbs have indeed been developed; the demand for herbal medicines is rapidly increasing due to their lack of side effects as shown in Table. There is currently developing scientific proof that plants obtain a vast and intricate arsenal of active ingredients (photochemical) capable of not only calming or smoothing the skin but actively restoring, healing, and protecting the body.⁴¹

***Avena sativa* (Oat)**

Avena sativa (also known as Oat)-derived compounds have been found to act as abrasives, antioxidants, skin conditioners, absorbents, and bulking agents in cosmetics. With 499 recorded applications in cosmetic goods, Oat kernel extract is the most commonly used in face and neck products. Oat kernel extract had the highest reported use concentration of 25 percent, whereas Oat kernel flour had the greatest use concentration of 84.4 percent in skin cleansing products. There was no evidence of irritation when a lotion containing an extract of young plants was applied to dry skin.⁴²

Aloe vera

While similarly related aloes may be found in Northern Africa, *Aloe Vera* is a *liliaceae* family herbal medication that is only found in cultivation, with no naturally occurring populations. It can be

found in moisturizers, face cleansers, and acne-fighting creams, among other cosmetics. Simply cut one of the *Aloe Vera* leaves to get the soothing gel. It has antioxidant characteristics and as well as vitamins A, C, E, B, choline, B12, and folic acid.^{20,21}

***Calendula officinalis* (Marigold)**

Marigold has traditionally been used to treat inflammation, irritation, redness, and even dry skin. The essential oil and distilled flower water of marigold are both thought to be particularly helpful in reducing ultra-violet damage and preventing the appearance of wrinkles. One of the trials conducted on 34 individuals with venous leg ulcers to investigate the therapeutic effectiveness of ulcers found that generating epithelialization significantly accelerated wound healing. When tested on healthy human volunteers, research on cream compositions comprising seven distinct kinds of marigold extracts demonstrated that they are efficacious in experimentally generated irritating contact dermatitis.⁴³

***Acorus calamus* (Muskrat root)**

Acorus calamus, sometimes known as "Muskrat Root," is a semiaquatic, perennial, fragrant herb with spreading rhizomes. Even as an essential oil, *A. calamus* root has a refreshing function to play in personal care, notably for hydrating the skin.^{12,19}

***Bauhinia racemosa* (Kanchivala or Bidi leaf tree)**

Bauhinia racemosa is a kind of small, crooked, bushy deciduous tree with drooping branches that thrives in the hardest of environments. This species may be found all throughout India and grows in the western Himalayas. *B. racemosa's* sweetish and astringent bark and leaves are used to cure headaches, fevers, skin disorders, blood illnesses, dysentery and diarrhoea.⁴⁴ The versatile medicinal plant *B. racemosa* is a one-of-a-kind source of a wide range of chemicals with different chemical structures.

***Emblica Officinalis* (Amla)**

Emblica officinalis, also named as Indian gooseberry, Amla in Hindi, and Amaliki in Sanskrit, is a plant that grows throughout India. Its fruit, which is a high nutritional source of ascorbic

acid, other minerals, amino acids, and phenolic compounds, is the most significant of the plant's various components used for food and medicine. For a long time, it has been used in Ayurveda and Unani medicine. Amla fruit has been demonstrated to have strong antioxidant capabilities and to protect human dermal fibroblasts from oxidative stress. As a consequence, it is recognized as a valuable and fascinating natural skin care component. It is being used to calm and balance stressed skin, and brighten the skin tone.⁴⁵

Summary

In clinical practice, contact dermatitis is a reasonably frequent ailment. However, an interdisciplinary team composed of a dermatologists, allergist, primary care provider, healthcare professional, and pharmacist is ideally suited to treat the problem. Because women use cosmetics more regularly, they are more likely to get contact dermatitis. Contact dermatitis induced by cosmetics was found in 88 percent of female patients.⁴⁶ The prevalence of contact dermatitis serves as a reminder that workplace preventative measures are possibly in need of improvement. Astringent soaks, topical or systemic steroids, and antihistamines are the best treatments for the acute phase of ACD. In exceedingly rare circumstances, such as when significant ulcers form as a result of serious acid or alkali accidents at work skin grafting may be required. In addition to topical steroids, moisturizing lotions for skin dryness are used to control the chronic phase. Antibiotics may be used if secondary infection is suspected. Irritation and allergy prevention and avoidance should be used in all situations.

CONCLUSION

Everybody's skin microflora is unique, and when many individuals share the same product, the risk of contamination increases. As a result, it is recommended that long-term usage of cosmetics, and sharing of public cosmetics should be avoided. In addition, it is necessary to encourage or mandate the use of personalized beauty kits in beauty salons, sanitary inspections in beauty salons.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

Not applicable.

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