



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 3, March 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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www.ijirset.com

Chemical Constitution of Cosmetics and Their Health Hazards

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ABSTRACT: Cosmetic products must not only promote healthy skin but also provide a beautiful tapestry of colors for every complexion. The state of the art in classical cosmetics is the use of finely crushed minerals and botanicals of the best quality. To suit even the most sensitive skin, these ingredients should be 100% pure and completely natural. However, most color additives to mass-produced cosmetic products are synthetic: indeed, unless specifically approved (such as annatto seed), all natural color additives are banned in the United States by the Food and Drug Administration to avoid irritation and hypoallergenic reactions. Cosmetic-grade color additives, either inorganic (pigments) or organic (dyes and pigments), are safe for use on humans and do not contain heavy metals such as lead, cadmium, and hexavalent chromium. The inorganic pigments include ultramarines, iron oxide, manganese, chromium oxide, titanium dioxide, and ferric ferrocyanide. Both organic and inorganic cosmetic-grade pigments are insoluble in both water and oil; however, they can be microscopically dispersed in a liquid host and made to appear as though they are dissolved. Only a few soluble dyes are used in cosmetic products because of the health hazards they may pose, especially if used in too high a concentration. For example, lakes are pigments manufactured by precipitating a soluble dye with a metallic salt (calcium salt, barium salt, aluminum salt, and sodium salt) because the different salts provide different colors.

Color additives can be combined with titanium dioxide and mica, bismuth oxychloride, or guanine. When combined with the titanium-dioxide-coated mica, they create very attractive dual-color pearls. Bismuth oxychloride is a soft material used as the frost in lipsticks. Guanine is derived from herring scales and is used primarily in nail polishes. In general, the mineral powders in the commercially available cosmetic products are based on titanium dioxide and zinc oxide, which, in addition to other technological reasons for their use, may also provide anti-inflammatory and calming effects.

KEYWORDS: cosmetics, constitution, health, color, hazards, heavy-metals, dyes, allergens

I. INTRODUCTION

Cosmetic products contain a wide range of chemicals to which we are exposed every day. The aim of the study was to determine the presence of potential dangerous substances which can cause adverse health effects by examining product labels. Fragrances are present in 52.3% of the examined products, mostly limonene (76.9%) and linalool (64.6%) but also citronellol (34.1%), geraniol (31.5%), coumarin (30%) and hexyl cinnamal (29.2%). Preservatives showed a rate of 60% and the most frequently identified were phenoxyethanol (48.7%), sodium benzoate (35.6%), potassium sorbate (22%), methylparaben (15.2%) and MI/MCI (9.9%). The other chemicals of concern were detected in 58% of products; included PEGs (62.3%), acrylate copolymer (34%), petrolatum (17.2%), polysorbates (14.8%), BHT (14.7%), ethylhexyl methoxycinnamate (13.6%), benzophenone-1 (3.7%), benzophenone-3 (4.9%), BHA (1.6%), cocamide DEA and toluene (1.2%).

The use of many of these substances is allowed within certain limits, due to their toxicity at higher concentrations. Other important aspects should be considered as, for instance, the possibility of long-term effects. On the other hand, other substances may induce several acute adverse side-effects, i.e. contact dermatitis and allergic reactions. For these reasons, an enhancement of the criteria used for cosmetics formulation is required since many chemicals used singularly or combined are potentially unsafe.[1,2,3]

In this study the presence of chemicals that can affect human health in consumer-available personal care and cosmetic products used by a large part of the population and frequently into contact with the body was examined.

More attention should be given to leave-on and make-up products which stay longer on the skin. For this reason, dangerous substances could determine greater negative effects on human's health. Make-up products, in particular, are often applied close to mucosa and frequently used by more sensitive categories, such as teenagers.

Fragranced ingredients are widespread diffused in cosmetic products but many of these may cause sensitizations, allergies and skin irritations [11]. For this reason, the EU established limits to their utilization and the obligation to indicate their presence on products labels, when the concentration is higher than 0.01% in rinse-off products, and 0.001% in leave on products [5].

The most common fragrance identified in the present study was limonene (76.9%) which, together with citral (24.2%), is classified as skin sensitizers (H317), according to the regulation on the classification, labelling and packaging of substances and mixtures (CLP) [16]. In addition, many fragrance ingredients were categorized as weak allergens [17]; since a large number of products contains a mixture of fragrances, the consumers are more likely to be exposed to mixtures of allergens. Bonefeld et al. [18] found that mixtures of fragrance allergens have an increased potency in sensitization and elicitation of contact allergy as compared with an isolated fragrance allergen.

Among preservatives, parabens are considered as a class of endocrine disruptors, especially propylparaben and butylparaben. Many studies observed that parabens were able to chemically imitate the oestrogenic activity leading to adverse health outcomes [19, 20]. Moreover, parabens could play a role in the development of human breast, ovary and testicles cancer [21, 22]. For these reasons, many countries have banned the use of some parabens in personal care products intended for newborns and children [23].

Formaldehyde-releasers are important sources of formaldehyde exposure and allergic Contact Dermatitis They are able to release formaldehyde that has the capability to cause hypersensitivity reactions [24]. For some time now, formaldehyde is considered carcinogenic to humans [25] and, even if concentrations of these kinds of preservatives added to cosmetics are very low, they are still present in a large number of products whose use occurs frequently and daily.[5,7,8]

MCI and MI are preservatives whose use has recently increased in cosmetics, but there is a limit of concentration both for the single ingredient and for the MI/MCI mixture [5]. Many studies focused on contact allergies associated with the use of MI/MCI, even if the dose allowed is respected [26, 27]. The use of chlorphenesin is allowed in concentration lower than 0.3% [28]. At a higher concentration it may cause irritations and contact dermatitis, especially on sensitive skin [29]. Due to the possibility of collateral side-effects on children, in particular on the respiratory tract and the central nervous system, the Food and Drug Administration (FDA) advised against the use of products containing chlorphenesin for children and women while breastfeeding [30]. In this work we underlined the presence of chlorphenesin in two children's products.

We found triclosan in few products, however, because of its relevance, it is important to focus attention on it. It is an antimicrobial additive considered potentially harmful for health as an endocrine disruptor, as a result of a prolonged use [31-33]. It may be found together with dioxin, formed during its synthesis process, which could also be formed by photodegradation of triclosan in the urban wastewater [34]. Moreover, the massive diffusion of this antimicrobial compound may determine an increase in the bacterial resistance to the most common antibiotics used in the medical field [35]. The widespread use of this substance is demonstrated by the detection of triclosan traces in fish's fatty tissues and, even worse, in maternal milk. That evidence confirms the continuous exposition to very low or minimal concentrations of triclosan may lead to living organisms to absorb that compound [36, 37]. For all these reasons, triclosan was banned in 2013 by the FDA [38]. Nevertheless, in Europe the use of triclosan is still allowed in cosmetic products.[9,10,11]

Lastly other chemicals, considered in our investigation, were substances different from fragrances and preservatives. Benzophenone-1 and benzophenone-3 are chemical filters used for the protection from UV radiations, reputed endocrine disruptors. Exposure to these ingredients, although definitive studies are lacking, could cause negative effects



on humans, as well as a neuronal delay and alterations in behavioural development, congenital malformations, fertility deficiency for men, etc. [39, 40]. In addition, the International Agency for Research on Cancer (IARC) classified benzophenone as a possibly carcinogenic to humans (2B group) [41]. These ingredients have good lipophilic properties and after only a few hours from their application on the skin, it is possible to detect them in biological fluids like maternal milk [42]. Also ethylhexyl methoxycinnamate is a UV filter added to cosmetics, and some studies show how it can affect and modify the regulation of the endocrine system [43].

Considering BHA and BHT, the Cosmetic Ingredient Review (CIR) Expert Panel established concentration limits for these substances (0.5% max) because of their uncertain toxicological profile and the potential irritating power on skin and mucosa [44, 45].

Cocamide DEA is a skin irritant [46], classified in 2B group by the IARC [47]. Moreover, in 2012 the California Office of Environmental Health Hazard Assessment added cocamide DEA to the list of chemical compounds that cause cancer [48].

PEGs are characterised by low cutaneous toxicity and generally they are weakly irritants. They come from the polymerization of ethylene oxide, a well-known carcinogenic agent [49]. These substances can contain residual impurities derived from the ethoxylation process: ethylene oxide, dioxane, polycyclic aromatic compounds, heavy metals like lead, iron, cobalt, nickel, cadmium, arsenic [50].

Petrolatum (indicated on labels as paraffinum liquidum/petrolatum/paraffin/vaseline/mineral oil) is widely used in cosmetics but there are some potential health risks linked to its utilization, especially for the possible presence of impurities. In 2011 a scientific study showed that hydrocarbons derived from petrolatum are the most present contaminants in human body and the contamination occurs, above all, through the inhalation of polluted air, [12,13,15] the ingestion of contaminated food and cutaneous absorption. This study also underlined that cosmetics can represent one of the most significant source of these compounds [51].

Toluene exposure from nail polish application was assumed to occur through both dermal and inhalation routes: a high concentration can cause irritation on the mucosa and skin irritation. It was listed in 1991 under State of California Proposition 65, as a chemical known for causing reproductive toxicity and having adverse effects on the central nervous system [52].

Finally, acrylates and polysorbates are considered weakly irritants: the concern related to the first compounds is the possible presence of toxic residuals like acrylic and methacrylic acid which are characterized by allergenic activity [53]; while the second ones are less irritants, even if cases of contact dermatitis due to these substances have been proved [54].

II. DISCUSSION

As a result of what explained, it is evident how, through the use of cosmetics, most people are exposed worldwide to a variety of potentially harmful substances.

Although the amounts may be small, and their effects sometimes poorly understood, continuous exposure to a mix of these chemicals over long periods could have consequences for the health and well-being of people and society. Actually, the current legislation takes these risks into account [17,18,19] and many substances are subject to a threshold concentration, but there is a potential “cocktail effect” due to the utilization of combined products during the daytime. In addition, the same substance can be found in more than one product and can derive from different sources (“additive effect”), in this way, the safety threshold established could be overcome. For example, we can think about formaldehyde which is found in a variety of consumer products: clothing, plastics, dry cleaning agents, paper, glue, drywall board, resins, wood panelling, etc.

It is necessary to improve the legislative approach, since there are chemicals whose use is not completely safe, but still allowed, so that it would be suitable to resort to the precautionary principle. Moreover, it would be appropriate to enhance cytotoxicity studies in order to assess the actual harmlessness of the formulations *in vitro* [51] and to prefer alternative substances [52] compared to those potentially dangerous used for the stability and the attractiveness of the products.

Minimal exposure level to arsenic can lead to serious illness or death [38]. Result from Chile establishes a dose-dependent relation between chronic arsenic exposure and various forms of cancer, especially when other risk factors, such as cigarette smoking, are joined. The effect is established to persist below 50 ppb of arsenic [39]. Studies on inorganic arsenic exposure suggest a small but measurable risk increase for bladder cancer at 10 ppb [40]. The acute poisoning effects of cadmium are nausea, vomiting, diarrhoea, headache and shock; inhalation of its dust and fumes can cause cough, respiratory distress, congestion of lungs and bronchopneumonia [41]. The metal accumulates in the liver and kidneys, damaging these organs when the exposure is chronic. Biological half-life of cadmium in humans is estimated at 20–30 years. Cadmium is listed by the United States Environmental Protection Agency [42] as one of the priority pollutant metal [43]. Absorption of lead into the skin is governed by chemical structure; therefore, skin organic lead absorption into the body tissues is more rapid than with inorganic lead compounds because of greater lipid solubility; large amounts of lead gain access to nerve tissue [44]. Acute effects of lead intake are ataxia, headache, vomiting, stupor, hallucination, tremors and convulsions.[20,21,22] Chronic cases include weight loss, anaemia, kidney damage and memory loss. Lead bioaccumulates in bones and teeth, and it is classified as an environmental priority pollutant by the US EPA. The safe level for drinking water is 15 µg/L [41].

Skin contact with nickel can cause dermatitis, and a type of chronic eczema known as ‘nickel itch’ is caused by hypersensitivity reactions of nickel on the skin [45]. Oral toxicity of nickel is very low, but ingestion results to hyperglycerine and depression of the central nervous system. Large dose inhalation of nickel dust can cause lung and sinus cancer in humans. Nickel and certain of its compounds are listed by International Agency for Research on Cancer (IARC) under group 2B carcinogens as possibly carcinogenic to humans [45].

Cr⁶⁺ is regarded as cancer-causing agent and is toxic [17]. It is corrosive to skin and causes denaturation and precipitation of tissue proteins. Chronic exposure may lead to cancer of the respiratory tract [17] and should be controlled in such a manner that no person is exposed to carcinogenic chromium (VI) at concentrations greater than 25 mg/m³ of air, determined as the time-weighted average (TWA) concentration limit for up to a 10-hour workday or a 40-hr work week, over a working lifetime [44]. Chronic inhalation of manganese dust or fumes can cause manganism, a nonfatal disease which affects the central nervous system. The symptoms are mental disorder and disturbance in speech [45].

Mercury can cause both chronic and acute poisoning. Case control studies have shown effects such as tremors, impaired cognitive skills and sleep disturbance in workers with chronic exposure to mercury vapour even at low concentrations in the range 0.7–42 µg/m³ [46, 47]. A study has shown that acute exposure (4–8 hours) to calculated elemental mercury levels of 1.1–44 mg/m³ resulted in chest pain, dyspnoea, cough, haemoptysis, impairment of pulmonary function and evidence of interstitial pneumonitis [48]. Occupational exposure has resulted in broad-ranging functional disturbance, including erythrim, irritability, excitability, excessive shyness and insomnia. In regular and consistent use, a fine tremor develops and may escalate to violent muscular spasms. Long-term, low-level exposure has been associated with more subtle symptoms of erythrim, including fatigue, irritability, loss of memory, vivid dreams and depression [49, 50].

In 2006, the United States Food and Drug Administration revoked the approval of the use of hydroquinone and proposed a ban on all over-the-counter preparations [51], because it felt that hydroquinone cannot be ruled out as a potential carcinogen. The reason was based on the absorption in humans and the incidence of neoplasm in rats shown by several studies in which adult rats showed increased rates of tumour development [51].

Extensive literature documentation reveals that hydroquinone can cause exogenous ochronosis, a disease that deposits blue-black coloration on the skin, if taken orally; but skin preparations containing the ingredient are administered topically [51, 52]. Although proper use of hydroquinone as skin lightening agent can be effective, it causes skin sensitivity. The effect can be minimized by daily use of sunscreen with a high persistent pigment darkening (PPD)

rating. Hydroquinone can be combined with alpha hydroxy acids which exfoliate the skin to quicken the lightening process. In the United States, skin creams usually contain up to 2% of hydroquinone, but higher amounts up to 4% or above should be prescribed and used with caution.

The most trending research and publication shows that minor constituents of other chemicals such as phthalates, parabens and phenols in personal care products (shampoos, toothpaste, soap, etc.), though not extensively discussed, can cause early puberty in young girls and boys. The chemicals can enter the body by cutaneous penetration through the skin, inhalation or accidental ingestion. A worrisome aspect is that exposure is very much possible through mothers during pregnancy and breastfeeding [53].

III. RESULTS

In human medicine, hydroquinone is used as a topical application in skin whitening to reduce the colour of skin by decreasing the production of melanin pigment in the skin. Since hydroquinone lightens the skin by reducing melanin, it simultaneously increases exposure of the skin to UV rays, thereby increasing skin cancer risks due to UV exposure [54]. It does not have the same predisposition to cause dermatitis as metals do. This use is banned in some countries, including the member states of the European Union under Directive 76/768/EEC: 1976 [50].

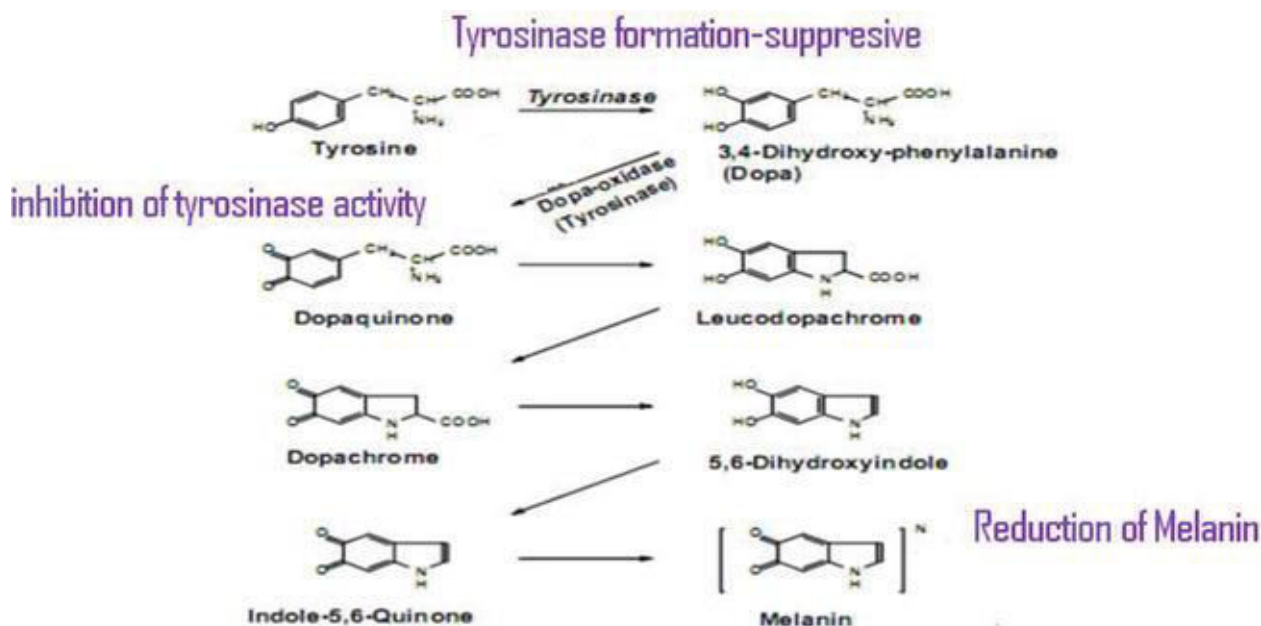
Clinical trials and experimental results prove that corticosteroids can cause permanent eye damage by inducing central serous retinopathy (CSR) or central serous chorioretinopathy (CSC) [5]. Different steroid medications, from anti-allergy nasal sprays (Nasonex, Flonase) to topical skin creams, eye drops (Tobradex) and prednisone, have been implicated in the development of CSR [38].

Corticosteroids have been applied on people with traumatic brain injury. In a systematic study in which the authors recommended that people with traumatic head injury should not be routinely treated with corticosteroids [52], side effects, such as cutaneous addiction with the development of uncomfortable and unsightly dermatoses, can occur with just one 15 g tube of moderate steroid over a period of 1 year [53].

The use of corticosteroids have severe side effects such as steroid psychosis [50], hyperglycaemia, insulin resistance, diabetes mellitus, osteoporosis, cataract, anxiety, depression, colitis, hypertension, ictus, erectile dysfunction, hypogonadism, hypothyroidism, amenorrhoea and retinopathy [51]. Evidence for corticosteroids causing peptic ulceration is relatively poor except for high doses taken for over a month [50]; majority of doctors as of 2010 still believe this is the case and would consider protective prophylactic measures [53]. Corticosteroids have a low but significant teratogenic effect, causing a few birth defects per 1000 pregnant women treated. [23,2,25]Corticosteroids are therefore contraindicated in pregnancy [51].

Nitrosamine has been established to cause cancer in animal species, which suggests that it may also be carcinogenic in humans. Available prove from case-control studies on nitrite and nitrosamine intake implicates it in gastric cancer (GC) risk and oesophageal cancer (OC) [28].

According to Lautenschläger [27], there is no hard evidence on carcinogenic effect of nitrosamine-contaminated products applied on the skin. The study suggests that it is limited to nitrosamines inhaled with cigarette smoke or those formed by sodium nitrite from nitrite cured food reacting with secondary amines from vegetables or other food components. The study stated that although there is no 100% protection, as secondary amines and nitrite also occur in the natural environment, however, as far as cosmetic products are concerned, it should be taken care that nitrosamines and their co-chemicals such as secondary amines and nitrites are not used in the formulation. It may be a fact that health risk involved with contaminated surface body care products may be ignored as they are not supposed to remain on the skin. Also, consumers can now have a sign of relief by drawing attention to the fact that the human system is equipped with its own secondary amines; therefore the skin can fight off any so as to protect itself with its natural moisturizing factor (NMF) which mainly contains amino acids. Chemical constituents of these amino acids are regarded as primary amines that can interact with NO₂, but when the molecule is destroyed in the process, nonhazardous nitrogen is normally formed.[25,27,28]



Nitrite is approximately 10 times more toxic than nitrate [52], and interaction of nitrite with haemoglobin occurs in the blood as methaemoglobin is formed; this compound drastically lowers oxygen carrying capacity of the blood; when this happens, it results to methaemoglobinemia or ‘blue baby syndrome’ in infants; this is caused by lack of acidity condition in the intestinal walls of infants that is supposed to kill or reduce the bacteria; as a result these bacteria convert nitrate into nitrite.[53] The most outstanding symptom of methaemoglobinemia is the appearance of a bluish colouration on the skin around the eyes and mouth as evidence of shortage of blood. The medical condition is treatable on early detection using methylene blue injection, which changes methaemoglobin back to haemoglobin, but death is sure when over 70% of the body’s haemoglobin has been replaced by methaemoglobin [29,30,31].

Exposure to heat can cause damage to any cosmetic or makeup products. It changes the chemical formula, evaporates water and separates oil composition from other ingredients (an occurrence referred to as creaming) [23]. It also encourages the emergence of a culture medium for bacteria. The effect of these changes on the skin is harmful as such cosmetic product would no longer satisfy its optimal role [28,32,33].

IV. CONCLUSIONS

You may be choosy about your moisturizer, hair color product, and makeup brand—but how much time do you spend checking out the safety of those products?

Cosmetics and personal care items include foundation and mascara, face and body lotion, soaps and shampoos, hair styling products, deodorant, toothpaste, hair dyes, and nail polish. They are considered safe, but that doesn't mean that there aren't risks associated with their use, particularly if you don't use them correctly.

Safety concerns

Some of the safety concerns that may be associated with cosmetics and personal care products include:

- Eye infections
- Spreading bacteria on the skin
- Irritation and scratches on the eye
- Fire hazards, in the case of aerosol products such as hairspray
- Allergic reactions or sensitivity to ingredients
- Contaminants in products not manufactured in the U.S.

Using your cosmetics and personal care products properly can help reduce many risks. These include washing off cosmetics before you go to sleep and not sharing any personal products to prevent the spread of bacteria.



Safety testing

The FDA works to ensure that cosmetic companies follow regulations to keep cosmetics and personal care products as safe as possible. But although the FDA recommends that cosmetic manufacturers test their products, they aren't required to do so. You can tell what's been tested by looking for a product label that says: "WARNING - The safety of this product has not been determined." If a product hasn't been tested for safety, it must display that labeling.

You may also see "external D&C," "D&C," or "FD&C" followed by the name of a color, for example "D&C Red No. 36." These are color additives. External D&C is only approved for use in cosmetics and in drugs that are applied to the skin. D&C color is only approved for use in drugs and cosmetics, but FD&C color is approved for use in foods, drugs, and cosmetics.

Two commonly used chemicals that have been scrutinized for safety are parabens and phthalates. Parabens are preservatives that prevent the growth of bacteria in personal care products and cosmetics. Although one study suggested a possible link between parabens and breast cancer, further studies have not reached the same conclusion. The levels of parabens used in personal care products today are considered safe, although parabens (and other ingredients) may cause irritation or an allergic reaction in some people.

Phthalates are used to enhance the formulas of a range of cosmetics and personal care products, from shampoo to hair spray to nail polish. They may be used as solvents and perfume fixatives or to help avoid stiffness in hair spray and reduce cracking in nail polish. Although phthalates have been extensively studied and reviewed, a number of panels have agreed that phthalates in these products are safe.

The FDA's role

The FDA regulates many of these products because items such as antidandruff shampoo, antiperspirants, and medicated lip balm are considered drugs. Color additives and dyes found in hair dye and cosmetics must also be approved by the FDA. The FDA also regulates personal care products that are categorized as medical devices, such as hair remover gadgets, dietary supplements, and consumer products like nail care tools.[33,35,37]

Although the FDA doesn't regulate nondrug cosmetics and personal care products, the agency can take legal action against companies that don't follow safety regulations when making these types of products. Companies must make sure that their products are safe before they can be sold.

Because the FDA can't actually approve most ingredients in cosmetics, personal care products can't be labeled or marketed as "FDA-approved." [52,53]

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