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Hazardous Ingredients in Cosmetics and Personal Care Products and Health Concern: A Review

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Abstract Increasing demand of cosmetics all over the world from teen to adult has increased awareness related to safety issue. The objective of this paper is to indicate the ingredients that possess health effect that can be found in cosmetics and personal care products. The ingredient was segmented to three parts which are preservatives, fragrances and heavy metal impurities. The related paper was reviewed in terms of the chemicals that commonly identified in the cosmetic and personal care product. This paper also highlighted the health risk possesses by such ingredients in the products. From the papers reviews, many chemicals remained arguable in term of safety and its presence in the products. The chemicals are either added for it intentional purposes or appears unintentionally due to the nature of chemical itself or due to the manufacturing processes. It is suggested that consumers aware over the ingredients used in their cosmetic and personal care products and the side effects it possesses.

Keywords Cosmetic, Preservative, Fragrance, Heavy metals, Health risk

1. Introduction

According to the Association of Southeast Asian Nations (ASEAN), cosmetics are defined as any substance or preparation intended to be placed in contact with the external parts of the human body or with the teeth and the mucous membranes of the oral cavity with a view exclusively or mainly for cleaning them, perfuming them, changing their appearance, and/or correcting body odours and/or protecting or keeping them in good condition [1]. Generally, cosmetics refer to all of the products used to care for and clean the human skin and make it more beautiful. The intentions of using cosmetic products is to maintain the body in a good condition, protect it from the effects of the environment and aging processes, change the appearance, and make the body smell nicer [2].

Cosmetics industry has grown by average 4.5% per year in the past 20 years. This industry was able to be one of the most stable industries despite the economic downturn is because of the demand that keep increasing all over the world [3]. Due to an increase in Gross Domestic Products (GDP), it was predicted the global beauty market to reach $265 billion in 2017. The expansion of global beauty market is influenced greatly by the increasing demand from Europe and Asia Pacific region [4].

With the economic benefit, it is a challenge to manufacturer to provide a good quality product with low cost and at the same time environmental friendly. Despite the positive news related with cosmetics and beauty industry, one cannot run from is the fact that the safety of the cosmetic used is always at top priority. Safety of the cosmetics has become the major concern [5]. Group of fragrances, preservatives, antioxidants, vehicles, ultraviolet absorbers, humectants, emollients, emulsifiers, acrylates, hair dyes, and nail polish components are the most common ingredients in cosmetics [6]. These additive chemicals are sometimes hazardous and prohibited due to the health risk it possess. Adverse reaction to beauty products are common reason a consumer was referred to hospital [2].

Most chemicals are added to cosmetic product in the form of preservatives and fragrances. Some of the preservatives and fragrance are toxic and prohibited from the usage as ingredients because it can cause cancer, mutation, reproductive toxicity, and endocrine disruption [2]. Heavy metals are also incorporated to beauty product for many purposes. The toxicity of heavy metals is well documented. At low concentration, some of these elements can cause damage to the internal body organ of animals and humans. Metal poisoning was reported to cause various mammalian cancers, respiratory diseases, failures in organ function and intellectual retardation [7].

This paper reviews the type of ingredients that present in the cosmetics and personal care products which can possibly risks human health. The ingredients that reviewed are various chemicals that are generalize under preservative, fragrance and heavy metal impurities. These chemicals added in products purposely to increase, enhance or improve

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the quality, longevity and odour to the appearance of the products.

2. Methodology

This review paper covers the related study from year 2000 to 2014. The total number papers referred to accomplish this paper review were 56 published papers. The total numbers of paper screened were 97 papers. Inclusions of the papers were based from the year the paper published and the papers fulfil the category listed. All the articles were searched through Google scholar and Scopus search engine. The keyword used to complete the paper finding were preservative, fragrance, parfum, perfume, heavy metals, trace element, personal care products, cosmetics, consumer products, health risk and human exposure.

The aspect focused in this paper is the common chemicals that possess health risk that presence in the cosmetics and personal care products. This section is divided to preservatives, fragrance and heavy metal impurities. Fragrances and preservatives are listed as the ingredient that can cause most of skin problems [8]. Heavy metal is focused as it has becomes a concern in recent years with increasing number of news related to it and study done to detect these elements in cosmetics. The concern over it has lead several countries to provide guideline for heavy metals impurities limit in cosmetics [9].

3. Hazardous Ingredients in Cosmetics

3.1. Preservatives

Most chemicals are added to cosmetic product in the form of preservatives and fragrances to increase the shelf life of the product and to have a good odour and appearance to the users [2]. Preservatives, the usual term for biocides used in cosmetics, are chemical compounds added to prevent the growth of microorganisms. They are intended to be added to clean products to prevent contamination by consumers while in use. They are not intended to make up for poor production hygiene or the use of contaminated raw materials and should not be used to treat contaminated products [10].

Table 1 list the example of preservatives detected in the cosmetic products. The most common preservative used is paraben (i.e. methylparaben, ethylparaben, propylparaben, butylparaben) and formaldehyde releaser (i.e. quaternium - 15, Dimethylol dimethyl hydantoin, imidazolidinyl urea, diazolidinyl urea). Parabens are the most common preservatives in the cosmetic especially on cream-based products. Cream basically consists of emulsions of water and oil, where water containing cosmetics are more prone to microbial contamination [10]. Paraben is antimicrobial mixture which prevent the microbial activity in cosmetic creams. A mixture of paraben with other classes of preservatives offer powerful antimicrobial activity against an extremely broad spectrum of microorganism [13]. Paraben have relatively low toxicity, good stability non-volatility, formulated well because they have no perceptible odour or taste, are practically neutral, do not produce discoloration, and do not cause hardening or "muddying" in cosmetic formulation [12]. Formaldehyde releasers commonly found in rinse-off cosmetics like shampoo. Formaldehyde releaser is substance in which it release formaldehyde by hydrolysis in the presence of water [21].

Table 1. Preservatives detected in previous study

Ref	Preservative detected	Products
[11]	2-phenoxyethanol	Aftershave balms
[12]	4-hydroxybenzoic acid	Anti-stretch marks cream
[13]	Benzalkonium chloride	Bath gel
[14]	Benzisothiazolinone	Body care product
[15]	Benzoic acid	Body milk
[16]	Benzyl alcohol	Cosmetics
[17]	Benzylparaben	Creams
[18]	Bronopol	Deodorant
[19]	Butylatedhydroxyanisole	Eye drop
[20]	Butylatedhydroxytoluene	Face cream
[21]	Butylparaben	Hair conditioners
	Cetrimonium chloride	Hand creams / gel
	Chlorhexidinedigluconate	Hand soaps
	Chlorhexidinedihydrochloride	Hygiene wash
	Chloroacetamide	Lanoline cream
	Chlorphenesin	Lipsticks
	Dehydroacetic acid	Liquid formulations
	Dimethylol dimethyl hydantoin	Liquid soaps
	Ethyl benzoate	Lotions
	Ethylparaben	Makeup
	Formaldehyde	Moisturizing creams
	Formalin	Multi-purpose cleaners
	Formic acid	Oil-based lotions
	Glutaral	Ointments
	Imidazolidinyl urea	Products for babies
	Iodopropynylbutylcarbamate	Shampoos
	Isobutylparaben	Shower gel
	Kathon CG	Skin cream
	Methamine	Skin milk
	Methylchloroisothiazolinone	Sun-related cosmetics
	Methyldibromoglutaronitrile	Toiletries
	Methylisothiazolinone	Washing-up liquids
	Methyloldimethylhydantoin	Water-based lotions
	Methylparaben	Wet tissues
	Octylisothiazolinone	
	Paraformaldehyde	
	Phenoxyethanol	
	p-hydroxybenzoic acid	
	Potassium sorbate	
	Propylparaben	
	Quaternium-15	
	Salicylic acid	
	Sodium benzoate	
	Sodium hydroxymethylglycinate	
	Sodium methylparaben	
	Sodium propylparaben	
	Sodium salicylate	
	Sorbic acid	
	Triclosan	
	α-Tocopherol (α-t)	
	α-Tocopherol acetate (α-ta)	

3.2. Fragrances

Fragrance chemicals are the most frequent sensitizer toward skin in cosmetics product [22]. Fragrance and flavour substances are organic compounds with pleasant odours. They are ubiquitously used in perfumes and other perfumed cosmetic products, as well as in detergents, fabric softeners, and other household products. Fragrance was used to mask unpleasant odours from raw materials [23].

Table 2. Fragrances detected in previous study

Ref	Fragrance detected	Products
[22]	2-phenylethyl isobutyrate	After-shave lotion
[23]	Allylheptanoate	After-sun creams
[24]	Alphaisomethyl ionone	Anti-cellulite creams
[25]	Amyl cinnamal	Anti-wrinkle creams
[26]	Anise alcohol	Baby gel / lotions/ creams
[27]	Atranol	Baby oil
[28]	Benzyl acetate	Baby wipes product
[29]	Benzyl alcohol	Bath foam
[30]	Benzyl benzoate	Deodorant (roll-on)
[31]	Benzyl cinnamate	Detergent
[32]	Benzyl salicylate	Emollient
	Butyl phenyl methyl propional	Fabric conditioner
	Chloroatranol	Foundation
	Cinnamal	Gels
	Cinnamyl alcohol	Hair conditioner
	Citral	Hand creams
	Citronellol	Hand soaps
	Coumarin	Insect repellent
	Eugenol	Lip care products
	Everniafurfuracea /tree moss	Lipstick
	Everniaprunastri /oak moss	Moisturizing creams
	Everniaprunastri extract	Moisturizing lotions
	Farnesol	Mouthwash
	Geraniol	Natural massage oil
	Hedione®	Perfume
	Hexyl cinnamal	Powder
	Hydroxycitronellal	Shampoos
	Hydroxyisohexyl3-cyclohexene	Shower gels
	Isoeugenol	Soap
	Lilial®	Sunscreen cream
	Limonene	Surface wipes
	Linalool	Toothpaste
	Linalyl acetate	Toy-cosmetic products
	Lyral®	Washing-up liquid
	Methyl 2-octynoate	Antiperspirants body sprays
	Methyleugenol	
	Pinene	
	Piperonal	
	Undecavertol	
	α-amylcinnamic aldehyde	
	α-hexylcinnamicaldehyde	
	α-isomethyl ionone	

The example of fragrance in cosmetic is limonene, linalool, hexylcinnamal and butylphenylmethylpropional. Table 2 lists the fragrance detected in cosmetics. Linalool and limonene are among the most frequent fragrance used in cosmetics formulation. Both of these fragrances can be found in many type of beauty products such as shampoos, hair conditioner, shower gels, rinse-off creams and lotions products.

Linalool is a naturally occurring terpene, present in large amounts in various plants. Pure linalool is not allergenic or a very weak allergen, but autoxidizes on air exposure and the oxidation products can cause contact allergy [61]. Limonene is one of the most inexpensive fragrance materials and used in large volumes for household products. This substance forms allergenic oxidation products during handling and storage [62]. The sensitizing potential of limonene increases with prolonged air contact at room temperature, when it is oxidized to allergenic derivatives [26].

3.3. Heavy Metals Impurities

Heavy metals can appear as impurities in finishing products. It is a byproduct during the cosmetics manufacturing process either formed by the breakdown of ingredients, or an environmental contaminant of raw ingredients [59]. It is acknowledged that heavy metal impurities in cosmetic products are unavoidable due to the ubiquitous nature of these elements, but should be removed wherever technically feasible [66]. In some countries for example Canada, heavy metals such as arsenic, cadmium, lead, mercury, beryllium, selenium, and thallium has been banned as intentional ingredients in cosmetics [34].

Despite of being banned, it can still be found in cosmetic products as trace amounts of this element are unavoidable under conditions of good manufacturing practice [38].

Some of heavy metal incorporated because of its function. For instance, press powder for eye shadow main ingredients are talc with pigments and zinc or magnesium stearate used as a binder. A metallic brilliant finish is created by copper, aluminium, brass, gold, or silver powders. Heavy metals such as cadmium, copper and lead retained as impurities in the pigments of eye shadows, or they are released by the metallic devices used during the manufacturing of products [38].

Table 3 lists heavy metals detected in cosmetic and personal care products as reported in previous study. The most common heavy metals detected in cosmetic products are lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), nickel (Ni) and copper (Cu). These heavy metals found in shampoo, lipstick, cream, eye shadow and powder. The type of ingredient used, the type of colorant used in decorative cosmetics and the inadequate purification of raw material influence the heavy metals impurities presence in cosmetics [48].

Table 3. Heavy metals detected in previous study

References	Heavy metals detected																						Products
	Pb	**Cd**	**Cu**	**Fe**	**Cr**	**Ni**	**Zn**	**Co**	**Al**	**Mn**	**Ti**	**Hg**	**As**	**Be**	**Se**	**Th**	**Ag**	**Sb**	**Ba**	**Bi**	**Sr**	**Mo**	
[35][7]	/	/	/	/	/	/	/	/															Surma (kohls), powder, cream, lipstick, shampoo, medicated and non-medicated soap and cream, hair cream
[33] [57] [65][39] [40][41] [42][43] [44] [45][59]	/	/	/	/	/	/	/	/	/	/	/	/	/					/					Lipstick, fairness cream, lip balm, anti-ageing cream, skin lightening cream, nail colour, skin cream
[34]	/	/				/							/	/	/	/							Foundation, concealer, powder, blush, mascara, eyeliner, eye shadow
[36] [37] [38]	/	/			/	/	/						/										Eye shadow, Eye pencil, eye liner, mascara, lipstick, lip gloss, native eyeliner
[46] [64]			/	/	/	/	/	/		/					/				/	/	/		Cream (face, body, hand), dried powder, body lotion, skin whitening, sunscreen, lipstick, eye shadow, dead sea black mud
[47][48] [49][50]	/	/	/		/	/	/	/	/	/		/	/				/		/	/		/	Lipsticks, Kohl (eyeliner), henna (hair dye or temporary tattoo), eye shadows, cream; freckles, moisturizing and foundation and face powders, talcum powder

4. Possible Health Effects

Cosmetics are an important cause of allergic contact dermatitis (ACD). Fragrances and preservatives are the two most clinically relevant allergens found in cosmetic products causes of contact allergy [6]. Fragrances account for 30–45% of allergic reactions to cosmetics [11]. Allergic reactions produce side effects include skin sensitivity, dermatitis, asthma attacks and migraine [53].

Fragrances are naturally a volatile chemical. Products that contain fragrance chemical will ends up in the air. The main focus of safety testing in fragrance industry is the effect to skin. Fragrance materials can penetrate the skin, absorbed into the bloodstream, and distributed to other organs. Ingestion is another route of exposure because many of the same materials are used as flavours in foods [54].

Contact allergy to fragrance ingredients occurs when an individual has been exposed to a sufficient degree of fragrance that cause allergy. Contact allergy is a life-long, specifically altered reactivity in the immune system. As a consequence, symptom such as allergic contact dermatitis may occur upon re-exposure to the fragrance allergens [23]. Allergic contact dermatitis is an inflammatory skin disease characterized by erythema, swelling and vesicles in the acute phase. If exposure continues it may develop into a chronic condition with scaling and painful fissures of the skin. Allergic contact dermatitis to fragrance ingredients is most often caused by cosmetic products and usually involves the face and hands. It may affect fitness for work and the quality of life of the individual. The frequency of contact allergy to fragrance ingredients in the general population in Europe is estimated between 1-3% [23].

Aside from fragrance, preservatives is also the major cause of contact dermatitis. Allergy toward preservatives effect area such as face, neck, hand and armpits. It can also cause health problem such as contact urticarial, an itching with swelling and redness in the skin [55].

Formaldehyde was once a common preservative used. The wide spectrum of antimicrobial action makes formaldehyde a good preservative. However, the use of formaldehyde in cosmetics and toiletries has decreased due to concern about its toxicity. Although the used of formaldehyde as preservatives has decreased for the past few years, the used of formaldehyde releaser has become a common practice [52]. Quarternium-15, imidazolidinyl urea, diazolidinyl urea, bronopol and dimethyloldimethyl (DMDM) hydantoin are formaldehyde-releaser that often used in cosmetic products. Non-formaldehyde-releasing substances also used as preservatives in consumer products. Methylchloroisothiazolinone or methylisothiazolinone (MCI/MI), methyldibromoglutaronitrile (MDBGN), and parabens (methylparaben, propylparaben, ethylparaben and butylparaben) are among the commonly used [55].

The safety of paraben as preservative has been reviewed by Cosmetic Ingredient Review (CIR) in 1984. It has been concluded that methylparaben, propylparaben, and butylparaben were safe for use in cosmetic products at levels up to 25%. Typically parabens are used at levels ranging from 0.01 to 0.3% [56]. A study by Darbre et al., has detected parabens in breast tumors [63]. The study also discussed on the weak estrogen-like properties of parabens and the influence on breast cancer, however, the study did not show that parabens can cause cancer. Although parabens can act similarly to estrogen, they have been shown to have much less estrogenic activity than the body's naturally occurring estrogen. Further, parabens are used at very low levels in cosmetics [56].

Heavy metals commonly presence in cosmetic and personal care products as impurities. That explain on the very lower concentration detected in it. As product impurities, their presence in cosmetics is not required to be on the label [34]. Although the presences of the toxic metals were in trace amount, these metals are known to be cumulative poison. The slow release of these metals into the human system may be harmful to the biological system if allowed to accumulate over time. These metals could accumulate in the body organs due to their long half-life [59, 7].

Table 4. Preservatives, fragrances and heavy metals that are allergen [58]

Fragrances			**Preservatives**	**Metals**
Group 1: Important sensitizers	Group 2: Less important sensitizers	Group 3: Rare sensitizers		
● Oak moss ● Tree moss ● Hydroxymethylpentylcyclohexenecarboxaldehyde (Lyral®) ● Hydroxycitronellal ● Isoeugenol ● Cinnamic aldehyde ● Farnesol	● Cinnamic alcohol ● Citral ● Citronellol ● Geraniol ● Eugenol ● Coumarin ● Lilial® ● Amyl-cinnamic alcohol ● Benzyl cinnamate	● Benzyl alcohol ● Linalool ● Methylheptin carbonate ● α-Amyl cinnamic aldehyde ● α -Hexyl cinnamic aldehyde ● Limonene ● Benzyl salicylate ● γ-Methylionon ● Benzyl benzoate ● Anisyl alcohol	● Isothiazolinones ● Methyl dibromoglutaronitrile (MDBGN) ● Formaldehyde or formaldehyde releaser ● Thiurams (Thiuram mix) ● Thiomersal	● Nickel ● Chromium and potassium dichromate ● Cobalt

At low concentration, some of these elements can cause internal body organ damage in animals and humans [40]. Pb and Cd are described as the most severe dangerous contaminants to ever presence in human civilization because they are distributed in the environment as polluting elements. The toxicity of lead and cadmium in continual exposure to relatively low levels may give adverse health effects both acute and chronic poisoning and pathological change of organs and diseases related to cardiovascular, kidney, bone, and liver [38]. Cr is an essential nutrient for human beings and animal as it plays important role. However inhaling large amount of Cr can cause stomach, kidney and liver problems. Hg is widely distributed in the environment by natural and anthropogenic sources [49]. Hg is not classified as a carcinogen in humans, however mercury chloride and methyl mercury are potentially carcinogenic in humans [57].

Some of heavy metals also known to be allergen. Metals that can caused allergic dermatitis is nickel (Ni), cobalt (Co), copper (Cu) and chromium (Cr) [46]. Considering the prolonged contact time of cosmetic products with the skin, the risk of allergic dermatitis contact might be increased [38]. Table 4 list preservatives, fragrances and heavy metals which are known to be allergen that commonly presence is cosmetic products.

5. Safety Assessment of Ingredient in Cosmetics

In risk characterization, uncertainty factor applies in the last phase of the safety evaluation for cosmetic substance. This uncertainty factor is defined as the Margin of Safety (MoS) and it is calculated by dividing the lowest non-observed adverse effect level (NO(A)EL) value of the cosmetic substance by its estimated systematic exposure dose (SED) [60] as in equation (1).

$$MoS = \frac{NO(A)EL(mg/kgbw/day)}{SED(mg/kgbw/day)} \quad (1)$$

World Health Organization (WHO) proposes a minimum value of 100 for MoS, and it is generally accepted that the MoS should at least be 100 to conclude that a substance is safe for use.

The NO(A)EL is defined as the highest dose or exposure level where no (adverse) treatment-related findings are observed. It is mainly derived from repeated dose animal studies (90 day, developmental toxicity studies, etc). The SED of cosmetic ingredients is the amount expected to enter the blood stream. It is expressed as mg/kg bw/day. Calculation of SED may be based either on percentage of substance penetrating the skin (equation 2) or absolute amount of substance penetrating the skin (equation 4) [60].

$$SED(mg/kgbw/day) = \frac{I(mg/day) \times DAp(\%) \times 10^{-2}}{60kgbw} \quad (2)$$

SED is calculated by dividing the I (mg/day) - the daily dermal exposure to the substance and DAp (%) - dermal absorption of the substance in percentage – by the default human body weight (60 kg bw) [60].

The calculation of the daily dermal exposure (I) of substance applied to the skin as in equation (3) is the amount of finished cosmetic product applied per application (A, g/application) times the, concentration of ingredients under study in the finished product (C, %) and the frequency of application of the substance (F, day^{-1}).

$$I = A(g/application) \times 10^{3}(\text{mg/g}) \times \text{C}(\%) \times 10^{-2} \times \text{F}(\text{day}^{-1}) \quad (3)$$

The SED also can be calculated using the formula in equation (4), where the dermal absorption of the substance reported as amount DAa ($\mu g/cm^2$) times the surface of skin area expected to be in contact with the cosmetic product SSA (cm^2) and the frequency of application of the substance F (day^{-1}) divided to default human body weight [60].

$$SED = \frac{DA_a(\mu g/cm^2) \times 10^{-3}(mg/g) \times SSA(cm^2) \times F(day^{-1})}{60kgbw} \quad (4)$$

Several ingredient has been calculated for the MoS. For example salicylic acid MoS was 133. The calculation of the margin of safety was performed according to the different uses of salicylic acid in cosmetic products. Salicylic acid was considered to be safe for "other uses" than as a preservative, at a concentration up to 2.0 % for the leave on and rinse-off cosmetic products and at a concentration up to 3.0 % for the cosmetic rinse-off hair products [51]. Scientific Committee on Consumer Safety (SCCS) has decided the relevance of MoS calculation on a case-by-case basis, taking into account the general toxicological profile of the substance, its toxicokinetic properties and its intended use [60].

6. Conclusions

In conclusion, many ingredients are incorporated into products for the beauty purposes. These ingredients help the development of complex formulations that improve the quality of human life in term of disease prevention, health maintenance, beauty enhancement and also building the self-esteem. The cosmetics industry is regulated, however only the basic guidelines are present [5]. As the industry keep expanding, and the related authority keep reviewing the safety of beauty ingredient and products, consumer should also play their role by keeping themselves updated with knowledge and aware of the ingredients presence in the products they used.

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