

## A REVIEW ON TOXICOLOGICAL ASPECTS OF HEAVY METALS USED IN COSMETICS

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### ABSTRACT

*Cosmetic products are composed of different organic and inorganic materials including hydrophilic and hydrophobic substances. In the manufacturing of coloured cosmetics, mineral pigments are commonly used which leads to the contamination of cosmetic products with heavy metals such as copper, nickel, lead, iron, mercury, arsenic and other elements. These Heavy metals become a part of cosmetic product intentionally in the form of pigments, preservatives, UV filters as well as antiperspirant, antifungal and antibacterial. It has been reported that human exposure to UV radiations can cause chronic as well as acute health effects on human skin, eye and immune system. The present review gives the brief insight on toxicological aspects of some of the heavy metals.*

**Keywords:** Cosmetics, Toxicity, Heavy metals.

## INTRODUCTION

According to the US Food and Drug Administration, cosmetics are defined as “articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to human body... for cleaning, beautifying, promoting attractiveness, or altering the appearance” [1]

Whereas Saudi FDA define the cosmetics as ‘any product contains one or more substance intended to use on the outer parts of the human body (skin, hair, nails, lips and the outer parts of the genital), teeth, and the mucous lining of the oral cavity for cleaning purposes, perfuming, to protect or keep the good condition, to change or improve appearance, or to change or improve the smell of the body.’ [2]

Cosmetics are classified based on widely used body parts as:

- Skin cosmetics: cleansing cream, cold/vanishing cream, powders, moisturizers and sunscreen, toner and deodorants.
- Hair cosmetics: Hair sprays, hair wax, hair volumizer, hair gel, hair colorants, shampoo, conditioner
- Face cosmetics: Primer, concealer, foundation, contour powder/creams, blusher.
- Eye cosmetics: Kajal, eye liner, mascara, eye brow pencil.
- Lip decorators: Lipsticks, lip glosses, lip plumper, lip balms, lip liner/lip pencil, lip paints.
- Nail cosmetics: Nail polish, nail polish removers, nail strengthener, cleanser, top and base coat, dehydrator.

Cosmetics designed for skin care can be used to cleanse, exfoliate and protect the skin, as well as replenish it, through the use of body lotions, cleansers, toners, serums, moisturizers, eye creams, retinal, and balms. Cosmetics designed for more general personal care, such as shampoo, soap, and body wash, can be used to cleanse the body. Cosmetics designed to enhance one's appearance (makeup) can be used to conceal blemishes, enhance one's natural features (such as the eyebrows and eyelashes), add colour to a person's face, and—in the case of more extreme forms of makeup used for performances, fashion shows, and people in costume—can be used to change the appearance of the face entirely to resemble a different person, creature or object. Techniques for changing appearance include contouring, which aims to give shape to an area of the face. Cosmetics can also be designed to add fragrance to the body. Products used for haircare, such as permanent waves, hair colours, and hairsprays are all classified as cosmetic products as well.

**HEAVY METALS IN COSMETICS:**

In cosmetics, heavy metals may be present as impurities in raw materials or as intentionally added ingredients. They can be found in various cosmetic products such as lipstick, eyeshadow, foundation, nail polish, and hair dyes. Heavy metals may serve different purposes in cosmetics, including pigmentation, preservation, and antimicrobial properties. Heavy metals such as lead, mercury, cadmium, arsenic and nickel, as well as aluminium, classified as a light metal, are detected in various types of cosmetics (colour cosmetics, face and body care products, hair cosmetics, herbal cosmetics, etc.). In addition, necessary, but harmful when they occur in excessive amounts, elements such as copper, iron, chromium and cobalt are also present in cosmetic products. Metals occurring in cosmetics may undergo retention and act directly in the skin or be absorbed through the skin into the blood, accumulate in the body and exert toxic effects in various organs. Some cases of topical (mainly allergic contact dermatitis) and systemic effects owing to exposure to metals present in cosmetics have been reported. Literature data show that in commercially available cosmetics toxic metals may be present in amounts creating a danger to human health. [3]

Types of heavy metals and their effect on human health with their permissible limits: [4]

S. No	Heavy Metal	Type of Cosmetic	Permissible Level [Mg/L]	Effects
01	Mercury	in lightening creams, mascaras, nail polish, lipsticks and kajal, body lotions, hair shampoos and conditioners, cleanser, lotions, hair dyes and creams, beauty cream, skin lightening cream and sunblock cream.	0.01	in burns, damage to the kidney, severe brain damage and damage to vision, tremors, gingivitis, minor psychological changes, acrodynia characterized by pink hands and feet, spontaneous abortion, damage to nervous system, protoplasm poisoning.
02	Lead	lipsticks, lip glosses, eyeliner, hair dyes, nail	0.1	renal dysfunction, lung cancer, lung disease, bone defects

		polish, kajal, eye brow pencils, mascaras, make - up foundation, face paints ace creams, body lotions, hair shampoos and conditioners, cleanser, lotions, hair dyes and creams, beauty cream, skin lightening cream and sunblock cream.		(osteoporosis, osteocalcin), hypertension, kidney damage, bronchitis, GI disorders, cancer mental retardation in children, developmental delay, fatal infant encephalopathy, congenital paralysis, sensor neural deafness and acute or chronic damage to the nervous system, epilepticus, liver, kidney, GI damage.
03	Nickel	osticks, eye-shadows, eye brow pencils and eye liners, mascaras, make - up foundation, face paints, face creams, body lotions, hair shampoos and conditioners, cleanser, lotions, hair dyes and creams, beauty cream, skin lightening cream and sunblock cream.	0.2	usea, vomiting, diarrhoea, headache, cough and shortness of breath
04	Cadmium	osticks, eye -shadows, eye brow pencils and eye liners, mascaras, make - up foundation, face paints, face creams, body lotions, hair shampoos and conditioners, cleanser, lotions, hair	0.06	nal dysfunction, lung cancer, lung disease, bone defects, hypertension, kidney damage, bronchitis, GI disorders, cancer mental retardation in children, developmental delay, fatal infant encephalopathy, congenital paralysis, sensor

		dyes and creams, beauty cream, skin lightening cream and sunblock cream.		neural deafness and acute or chronic damage to the nervous system, epilepticus, liver, kidney, GI damage.
05	Chromium	colorants of eye shadows, blushes, eye brow pencils and eye liners	0.05	ancer, fatigue, irritability and damage to the nervous system.
06	Arsenic	lipsticks, eye shadow, lotions, eye brow pencils and eye liners, mascaras, make -up foundation, face paints, face creams, body lotions, hair shampoos and conditioners, cleanser, lotions, hair dyes and creams, beauty cream, skin lightening cream and sunblock cream.	0.02	in effects, circulatory and peripheral nervous disorders, lung cancer, GI and urinary system cancers.
07	Iron	face powders, lipsticks	0.3	bleeding

**Arsenic:**

Arsenic is a metalloid that is present ubiquitously as a major contaminant in the environment. Although, it is redox inactive, its target functional groups are sulfhydryl groups on proteins which may lead to the depletion of glutathione, an essential antioxidant of an amino acid origin, which prevents damage of cellular components caused by radicals and heavy metals. Arsenic is harmful because of its strong affinity for skin and keratinizing structures such as hair and nails. Symptoms of acute overexposure include a variety of skin eruptions, baldness, and distinctive nail striation. Arsenic does not serve as a sensitizer since its naturally occurring compounds have a low skin penetration capacity. Depending on the form and composition, arsenic can have different negative impacts on human health. There are no known harmful health effects of metallic arsenic, and it is not absorbed by the digestive system. Only its inorganic form has been

shown to be carcinogenic. Compared to organic arsenic found in the environment, inorganic arsenic compounds (such dimethylarsinate) are more acutely poisonous. Very little dermal absorption is anticipated. According to one study, cutaneous exposure. One study predicted that dermal exposure to arsenic may contribute less than 1% of the exposure from ingestion. [5]

### **Mercury**

Mercury is one of the heavy metals that is widely used in cosmetic formulations. Although, mercury is known as a shiny, silvery, dense liquid, it may occur in various inorganic and organic compounds. In the inorganic form, such as ammonia-ated mercury, it is used for its skin lightening properties, where as in the organic form, such as phenyl mercuric and ethyl mercuric salts, it is used as a preservative in mascaras and eye makeup cleansing products. After dermal application, mercury penetrates through the skin via the hair follicles and sweat glands. During this process, part of the mercury is reduced to the metallic form that accumulates in the skin tissue. Mercury blocks tyrosinase in situ, inhibiting the melanin-forming enzyme, hence its use in skin-lightening creams. The literature on the health effects of mercury is extensive. Most of the literature focuses on effects following inhalation exposure to metallic mercury vapours and oral exposure to inorganic and organic mercury compounds. There is limited information on adverse effects following dermal exposure to ointments and creams that contain inorganic mercury compounds. Various forms of mercury are toxic. The form of mercury plays a role in how much is absorbed via dermal or oral routes. Organic (methyl) mercury is of greater concern than inorganic mercury; however, all forms of mercury are absorbed through the skin and mucosa, and dermal exposure can result in systemic toxicity. For the general population, the major route of mercury exposure is dietary intake. Mercury compounds may cause allergic reactions, skin irritation, or adverse effects on the nervous system. Clinical symptoms of overexposure to mercury include tremors, weakness, memory loss, dermatitis and impaired kidney function, with the form of mercury typically determining the specific symptoms. [6]

### **Cadmium:**

Cadmium is one of the metals that has been used in cosmetics for its coloured salts, ranging from deep yellow to orange. It has been associated with several toxicities in humans, mainly attributes to its absorption after topical application of several cosmetics though this is very low (0.5%). Topically, it may cause irritant dermatitis. The main concern with Cd is that it tends to accumulate in humans' tissues and then release slowly into the general circulation. However, it normally binds to the keratin. Systematically, it mainly affects the skeletal, reproductive,

metabolic, respiratory and renal system. It has been associated with osteoporosis, diabetes, lung cancer and kidney damage. It contributes also to skin ageing as it may provoke oxidative stress. Despite of its presence in cosmetics, it may be found in several sources such as industrial wastes, agrochemical (pesticides and fertilizers) and batteries. Cadmium is classified as a human carcinogen by the National Institute for Occupational Safety and Health (NIOSH). Absorption of cadmium through the skin is low (0.5%) and would be of concern only in situations where concentrated solutions would be in contact with the skin for several hours or longer. Cadmium binds to epidermal keratin when applied topically, thus explaining the limited dermal absorption observed in vitro. However, significant dermal exposure as could occur in an occupational setting can cause irritant dermatitis. [7]

**Lead:**

Lead combines with sulfhydryl enzymes leading to interference with their action. It decreases haem synthesis by activating the enzymes involved such as aminolaevulinic acid dehydrase, aminolaevulinic acid synthetase, coproporphyrinogen oxidase and ferrochelatase. This results in anaemia. Lead increases haemolysis as a result of which immature red cells are released into circulation such as reticulocytes and basophilic stippled cells (the result of aggregation of ribonucleic acid due to inhibition of the enzyme pyrimidine-5-nucleotidase which normally eliminates degraded RNA). In the CNS, lead causes oedema and has a direct cytotoxic effect leading to decreased nerve conduction, increased psychomotor activity, lower IQ, and behavioural/learning disorders. Children are especially susceptible. The highest brain concentrations, of lead are found in the hippocampus, cerebellum, cerebral cortex and medulla. Lead also has deleterious effects on the CVS (Hypertension, myocarditis), kidney injury (nephritis), and reproductive organs (infertility). Interstitial nephritis, reduced glomerular filtration rate, and nonspecific proximal tubular dysfunction are typical. Lead can decrease uric acid renal excretion, thereby raising blood urate levels and predisposing to gout (saturnine gout). Elevated urinary levels of N-acetyl-3-D-glucosaminidase and  $\beta$ -2-microglobulin may serve as early markers of renal injury. Lead exerts adverse effects on numerous organs and systems including the central nervous system (CNS), the kidneys and on the hematopoietic (blood forming) system. Exposure to lead is typically greater in children, who are also more susceptible to the effects of lead than adults. Children are particularly at risk for the subtle adverse effects of chronic low-dose lead exposure, as are pregnant women/foetuses. Children absorb about 50% of ingested lead. The identification of causal relationships between exposure and effects is

complicated by the delay between the time of lead exposure and the onset of effects. Dermal absorption of inorganic lead has been demonstrated in animals and human subjects; however, few studies have provided quantitative estimates of dermal absorption and the contribution of the dermal intake to lead body burden. Inorganic lead crosses the skin less readily with a low permeability co-efficient of about 10<sup>-4</sup> cm/hour. Exposure to lead from cosmetics previously occurred from use of progressive hair dye preparations containing lead acetate. [8]

#### **Nickel:**

Nickel is one of the metal impurities which is inevitably found in several natural ingredients used in cosmetic products. Most of the salts containing nickel are green I colour, hence also its potential use as a colorant. However, nickel is considered to be a contact allergen that may provoke dermal sensitization, allergies, and dermatitis by direct and often prolonged exposure. Persons have been diagnosed with nickel allergy due to its presence in topical cosmetic products and jewellery. Nickel may also affect the respiratory system which may result in nasal and lung cancer. Despite of the potential use of cosmetics to maintain the skin in a rejuvenating state, nickel in such products may lead to oxidative stress and hence promote skin aging. This may be due to the over-expression of collagen in the skin leading to the weakening of the skin matrix and a subsequent loss in elasticity. International Agency for Research on Cancer has been classified metallic nickel as a potential carcinogen to humans and its compounds as carcinogenic. [9]

#### **Iron:**

Iron oxides used in cosmetic products is an inorganic compound consisting of any one or combinations of synthetically prepared iron oxides that includes hydrated forms of iron oxides. In cosmetics and personal care products, iron oxides are used in the formulation of a wide variety of product types, including makeup and skin care preparations. Iron oxides impart a colour to cosmetics and personal care products. Depending on the specific iron oxides or mixtures of iron oxides used, the colour will vary from orange, red, yellow to black. Excessive exposure to iron causes Massive post-arteriolar dilation which results in venous pooling. Increased capillary permeability resulting in decreased plasma volume. Oxidation of ferrous to ferric iron releasing hydrogen ions. Subsequent hydration of ferric iron results in metabolic acidosis. Inhibits mitochondrial function leading to hepatic damage, hypoglycaemia and hypoprothrombinaemia. Inhibits thrombin-induced conversion of fibrinogen into fibrin. Has a direct corrosive action on the GI mucous. Iron has shown evidence indicate iron necessary, but harmful when they occur in excessive amounts, elements are present in cosmetic products. [10]



## CONCLUSION:

Owing to the growing usage of cosmetics it is necessary to pay special attention to these problems.

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