



Article title: Review of Toxic Chemicals in Cosmetics

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Review of Toxic Chemicals in Cosmetics

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ABSTRACT

Aim of this article is to review the literature about toxic chemicals in cosmetics, to emphasize the importance of toxicological research in cosmetology and to support the campaign for safe cosmetics. There is a need for the establishment of higher standards in cosmetology in a way of raising awareness about toxic chemicals that should be avoided, promoting safer cosmetics and transforming cosmetic industry into safe and non-toxic.

INTRODUCTION

Today's life is unimaginable without the use of many cosmetic and cosmeceutical products, some of which have toxic chemicals that should be avoided. The role of toxicology in cosmetic and cosmeceutical industry is to ensure that toxic ingredients are avoided and replaced with less toxic, or even better, non-toxic chemicals. The importance of the campaign for safe cosmetics is to raise awareness about toxic chemicals in cosmetics, promote safety standards and stimulate the transformation of cosmetic industry into safe and non-toxic.

1,4-DIOXANE

1,4-dioxane, a carcinogen linked to organ toxicity, may be found in as many as 22 percent of the more than 25,000 cosmetic products in the Skin Deep database¹.

It is not marked on ingredient labels because it is a contaminant produced during manufacturing. It is found in products that create suds such as shampoos, liquid soaps, bubble baths, hair relaxers...

1,4-dioxane is generated through a process called ethoxylation, in which ethylene oxide, a known breast carcinogen, is added to other chemicals to make them less harsh². Research shows that 1,4-dioxane readily penetrates the skin³. It is considered a probable human carcinogen by the U.S. Environmental Protection Agency⁴ and is listed as an animal carcinogen by the National Toxicology Program⁵. It is included on California's Proposition 65 list of chemicals known or suspected to cause cancer or birth defects⁶.

ACRYLATES

Acrylates (ethyl acrylate, ethyl methacrylate, and methyl methacrylate) are ingredients found in artificial nail products (acrylic nails, nail enhancing polishes). Inhalation and skin contact are two main exposure routes. Despite evidence of adverse skin, eye, and throat reactions to these chemicals, they continue to be used in nail products².

The International Agency of Research on Cancer (IARC) and U.S. Environmental Protection Agency (EPA) classify ethyl acrylate as a possible human carcinogen^{7, 8}.

Workers in acrylic sheet manufacturing exposed to both high and low levels of methyl methacrylate (MMA) were at an increased risk of colorectal cancer⁹.

Orthopedic surgeons are chronically exposed to MMA and are proportionately more likely to die from cancer, especially esophageal and myeloproliferative cancers, than general surgeons¹⁰.

MMA inhalation is toxic to lungs¹¹ and is associated with damage to nasal passages, liver, and kidneys¹². Ethyl acrylate is toxic to the lungs, liver, kidneys, and gastrointestinal system¹³. Two studies showed that occupational exposure to MMA can cause symptoms of generalized and peripheral nerve damage^{14, 15}.

Acrylates are skin, eye, and respiratory tract irritants, and can cause workplace-induced asthma (occupational exposure) and allergic contact dermatitis (artificial nails that contain acrylates²).

BENZOPHENONE

Benzophenone is used in personal care products such as lip balm and nail polish to protect the products from UV light. Derivatives of benzophenone, such as benzophenone-2 (BP2) and oxybenzone (benzophenone-3 or BP3) are common ingredients in sunscreen².

Benzophenone is persistent, bioaccumulative and toxic^{16, 17}. It is considered to be a possible human carcinogen¹⁸ and possible endocrine disruptor¹⁹. The European Food Safety Authority (EFSA) classifies benzophenone as a known toxicant because it can cause liver hypertrophy in the rat at lower doses²⁰. Oxybenzone can permeate across the skin and accumulate in blood, kidneys and liver in rats, and may be hepatotoxic²¹.

BUTYLATED COMPOUNDS

Butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are used as preservatives in a variety of personal care products (lip and hair products, makeup, sunscreen, antiperspirants, deodorants, fragrances, creams²).

According to European Commission on Endocrine Disruption there is strong evidence that BHA is a human endocrine disruptor. A study carried out in normal mammalian kidney cells found that exposure to BHA caused specific damage at the cellular level and was found to exert a significant cytotoxic effect even at low doses²². IARC determined that there was only limited evidence of carcinogenicity for products used on the lips. There is moderate evidence that BHT is a human respiratory irritant².

CARBON BLACK

Carbon black is a dark black powder used as a pigment in cosmetics such as eyeliner, mascara, lipstick, nail polish, eye shadow, brush-on-brow, blushers, rouge, makeup and foundation².

IARC classifies carbon black as possible human carcinogen. Several human studies indicate carbon black exposure may increase the risk of lung disease²³.

Data from the study on rats conducted by Kim and coworkers showed that carbon black exposure enhanced the cardiovascular risk by inducing hyperhomocysteinemia and platelet hyperactivity, although these effects may be variable depending on particle size and exposure duration. Homocysteine may be a

potential biomarker for cardiovascular toxicity following carbon black exposure²⁴.

COAL TAR

Coal tar is a known human carcinogen found in shampoos and scalp treatments, soaps, hair dyes and lotions².

Occupational exposure to coal tar or coal-tar pitch increases the risk of skin cancer. Other types of cancer (lung, bladder, kidney and digestive tract cancer) have also been linked to occupational exposure to coal tar and coal-tar pitch²⁵.

Pyridine, a coal tar constituent, has been linked to neurological damage. Effects include emotional and sleep disturbances, as well as loss of coordination^{26,27}.

ETHANOLAMINE COMPOUNDS

Ethanolamine compounds are present in soaps, shampoos, hair conditioners and dyes, lotions, shaving creams, paraffin and waxes, household cleaning products, pharmaceutical ointments, eyeliners, mascara, eye shadows, blush, make-up bases, foundations, fragrances, and sunscreens. The European Commission prohibits diethanolamine (DEA) in cosmetics, to reduce contamination from carcinogenic nitrosamines that are formed after the reaction of DEA with other ingredients².

DEA and TEA (triethanolamine) have been found to be hepatocarcinogenic in female mice^{28, 29}. Studies have found that DEA affects human male reproductive health. It alters sperm structure, causing abnormalities that affect the sperm's ability to swim and fertilize the egg³⁰.

DEA accumulates in the liver and kidney, causing organ toxicity. It has also possible neurotoxic effects such as tremor³¹. Another study suggests that memory function and brain development in offspring could be permanently affected by mothers' exposure to DEA³².

ETHOXYLATED INGREDIENTS

Ethoxylated ingredients are found in shampoo, liquid soap, bubble bath and hair relaxers². Ethoxylated ingredients are generally of low concern on their own, but they can be contaminated with ethylene oxide, a known human carcinogen. Lymphoma and leukemia are the cancers most frequently reported to be associated with occupational exposure to ethylene oxide, but stomach and breast cancers may also be associated with it³³.

FORMALDEHYDE

Formaldehyde and formaldehyde-releasing preservatives are found in nail polish, nail glue, eyelash glue, hair gel, hair-smoothing

products, baby shampoos, body soaps, body wash, and color cosmetics².

Formaldehyde is a known human carcinogen. Studies of workers exposed to high levels of formaldehyde, such as industrial workers and embalmers, have found that formaldehyde causes myeloid leukemia, and cancers of the paranasal sinuses, nasal cavity and nasopharynx³⁴.

Formaldehyde is also the 2015 American Contact Dermatitis Society contact allergen of the year³⁵.

FRAGRANCE

The International Fragrance Association (IFRA) lists 3,059 materials that are reported as being used in fragrance compounds. Of these 3,059 ingredients, some (such as acetaldehyde, benzophenone, BHA, BHT, benzyl salicylate, benzyl benzoate, butoxyethanol, butylphenyl methylpropional, methyl chloride, methylene chloride, diethyl phthalate, essential oil mixtures, methyleugenol, formaldehyde, ethanolamines, methanol, oxybenzone, propyl paraben, resorcinol, styrene, synthetic musks, titanium dioxide, 1,4-dioxane, ethylbenzene and vinyl acetate) have evidence linking them to health effects including cancer, reproductive toxicity, allergies and sensitivities^{2, 36}.

HOMOSALATE

Homosalate is a widely used chemical in sunscreens and skin care products with sun protecting factor (SPF). It is a potential endocrine disruptor (impacts androgen and progesterone systems) and it may enhance the absorption of pesticides in the body².

In human breast cancer cells homosalate exposure led to 3.5 times more cell growth and multiplication³⁷.

HYDROQUINONE

Hydroquinone is most commonly used in skin lighteners, products heavily marketed towards women of color. It is also found in skin lighteners, facial and skin cleansers, facial moisturizers, hair conditioners, and finger nail coating products².

Hydroquinone decreases the production and increases the degradation of melanin pigments in the skin, what increases the skin's exposure to UVA and UVB rays, and the consequence is increased risk of skin cancer³⁸. Hydroquinone is linked to a skin condition called ochronosis in which the skin thickens and turns bluish-grey³⁹. Exposure of the eye can cause pigmentation and permanent corneal damage⁴⁰. Hydroquinone may be harmful if inhaled, causing irritation of the nose, throat and upper respiratory tract.

A study on occupational exposure of hydroquinone showed that subjects exposed to hydroquinone had a higher prevalence of cough and decreased lung capacity compared to their unexposed counterparts⁴¹.

HEAVY METALS

Heavy metals like lead, arsenic, mercury, aluminum, zinc, chromium and iron are found in a wide variety of personal care products including lipsticks, whitening toothpaste, eyeliners, nail colors, foundations, sunscreens, eye shadows, blushes, concealers, moisturizers, and eye drops². Lead is a well-known and proven neurotoxin that has been linked to learning, language and behavioral problems⁴².

Lead has been linked to reduced fertility in men⁴³ and women⁴⁴, hormonal changes and menstrual irregularities. Pregnant women are especially vulnerable because lead crosses the placenta and may enter the fetal brain, and has also been linked to miscarriage⁴⁵.

Mercury is linked to nervous system toxicity, as well as reproductive, immune and respiratory toxicity, and is a recognized environmental health concern by numerous national and international government bodies⁴⁶. Mercury may also disrupt thyroid hormones⁴⁷.

Aluminum-based compounds vary in their toxicity, but some are linked to neurotoxicity, developmental and reproductive toxicity, and cancer⁴⁸.

Excess chromium levels (chromium is an essential trace element in human body, it is important factor for enhancing insulin activity) are strongly linked to immune and respiratory toxicity, as well as systemic toxicity⁴⁹.

MIT, CMIT

Methylisothiazolinone (MIT) and methylchlorisothiazolinone (CMIT) are found in shampoos, conditioners, hair colors, body wash, lotions, sunscreens, mascaras, shaving creams, baby lotions, baby shampoos, hairsprays, makeup removers, liquid soaps and detergents².

Rats exposed to highly concentrated MIT (over 50%) showed a range of symptoms, including significant body weight gain and death. Autopsies revealed that death was due to reddened lungs and swollen intestines⁵⁰. MIT and CMIT are two of the most predominant contact allergens found in cosmetic products⁵¹.

In vitro cell studies on MIT showed signs of neurotoxicity when cerebral cortex cells were exposed to liquid MIT⁵².

MICA

Mica is a naturally occurring mineral dust often used in makeup foundations, as filler in cement and asphalt, and as insulation material in electric cables². Mica is a respiratory irritant. Long-term inhalation of mica dust may cause lung scarring which leads to symptoms such as coughing, shortness of breath, weakness, and weight loss⁵³.

NAIL POLISH REMOVERS

Isopropyl acetone, methyl ethyl ketone, and n-methyl-pyrrolidone, are commonly used as the solvent in nail polish removers. These chemicals are skin, eyes and respiratory irritants. There is some evidence about possible carcinogenicity of isopropyl acetone².

NANOPARTICLES

Insoluble nanoparticles in cosmetic products are essentially used as UV-filters or preservatives. Nanoparticles can be found in deodorants, toothpastes, shampoos, lotions, foundation, anti-aging creams, and nail polish².

Studies have indicated that low solubility nanoparticles (such as titanium dioxide, zinc oxide, silver, fullerenes, silica, carbon black) tend to be more toxic than larger particles of the same material⁵⁴.

Inhalation of nanomaterials may lead to inflammation and oxidative stress⁵⁵⁻⁵⁷.

NITROSAMINES

Nitrosamines can be found in nearly every kind of personal care product. Nitrosamines are probable human carcinogens (group 2A). There is also some evidence of endocrine disruption at very low doses². N-nitrosodiethanolamine, one form of nitrosamine, accumulates in the liver, bladder and other organs and leads to chronic toxic health effects⁵⁸.

OCTINOXATE

Octinoxate is an UV filter found in hair color products and shampoos, sunscreen, lipsticks, nail polish, and skin creams².

Octinoxate increases cell proliferation in cells that grow in response to estrogen exposure what can increase the risk of breast cancer^{59, 60}. Octinoxate can also reduce the level of thyroid hormones in blood serum⁶¹.

Numerous studies have reported that octinoxate exhibits antiandrogenic activity, which is linked to harmful effects on reproductive organ development in male and female fetuses exposed in utero².

PARABENS

Parabens are preservatives that can be found in shampoos, conditioners, lotions, facial and shower cleansers and scrubs².

Parabens are potential endocrine disruptors due to their ability to mimic estrogen. Combined with other estrogenic chemicals parabens may potentially influence the development of malignant melanoma through their estrogenic and genotoxic activities⁶². Some studies have also shown that parabens have potential developmental and reproductive toxicity².

PABA

PABA (para-amino benzoic acid) and PABA derivatives are commonly used in sunscreens as ultraviolet B (UVB) filters².

Studies performed on rats and on thyroid tissue samples suggest that PABA may disrupt thyroid activity⁶³⁻⁶⁵ by decreasing the levels of thyroxine.

UV radiation is more likely to damage DNA in the presence of PABA, and DNA damage to the skin increases the risk of skin cancer⁶⁶⁻⁶⁸.

PETROLATUM

Petrolatum, or petroleum jelly, derived from petroleum, is often used in personal care products (such as lotions) as moisturizing agent².

Petrolatum can be contaminated with toxic chemicals called polycyclic aromatic hydrocarbons (PAHs). IARC lists 14 PAHs as probable or possible carcinogens and one PAH as a known carcinogen⁶⁹.

PHENOXYETHANOL

Phenoxyethanol is used as a preservative in cosmetic products and also as a stabilizer in perfumes and soaps. It can be found in moisturizers, eye shadows, foundation, sunscreens, conditioners, mascaras, eye liners, shampoos, lip gloss, concealers, body wash, hand creams, blush, hair colors, hair sprays, lip balms, lotions, nail polish, baby wipes, baby lotions and soaps, soap (liquid and bar), shaving creams, deodorants, toothpaste, fragrance, hair removal waxes, hand sanitizer and ultrasound gel². Exposure to phenoxyethanol has been linked to reactions ranging from eczema⁷⁰ to severe, life-threatening allergic reactions⁷¹.

Infant oral exposure to phenoxyethanol can acutely affect nervous system function⁷².

POLYACRYLAMIDE

Polyacrylamide is used as a stabilizer and binder in lotions and other products. It can be found in facial moisturizers, anti-aging products, color cosmetics, lotions, hair products, and sunscreens. Polyacrylamide can break down into acrylamide, which is a

probable human carcinogen, and can be associated with reproductive and developmental toxicity².

POLYTETRAFLUOROETHYLENE (PTFE, TEFLON)

Polytetrafluoroethylene can be found in foundation, pressed powder, loose powder, bronzer, blush, eye shadow, mascara, shave gel, lip balm, and anti-aging lotion².

These products can be contaminated with perfluorooctanoic acid (PFOA) that is a possible human carcinogen (IARC).

PFOA exerts effects on the endocrine system, disrupting estrogen receptors, thyroid receptors, steroid hormones, and male testosterone levels⁷³⁻⁷⁵.

PFOA has also been linked to delayed puberty in girls, reproductive toxicity and inflammation².

P-PHENYLENEDIAMINE

P-phenylenediamine can be found in many forms of permanent hair dyes called oxidative dyes². German study showed that p-phenylenediamine was the fifth most common skin allergen and that it had about a 5% sensitization rate⁷⁶.

When p-phenylenediamine reacts with hydrogen peroxide, as it does in the preparation of hair dyes, it can form a mutagenic substance called Bandrowski's

base, which has been shown to be strongly mutagenic and possibly carcinogenic^{77, 78}.

When ingested, p-phenylenediamine is highly toxic. Often referred to as hair dye poisoning, it can cause respiratory distress and renal failure^{78, 79}.

PHTHALATES

Phthalates have been banned from cosmetics in the European Union, but still remain prevalent in U.S. products such as color cosmetics, fragranced lotions, body washes and hair care products, nail polish and treatment. These chemicals are linked to endocrine disruption, developmental and reproductive toxicity, and possibly to cancer².

QUATERNIUM-15

Quaternium-15 can be found in hair conditioners, hair styling products, creams, lotions, cleansers, shaving products, eye drops contact solutions and household cleaning products². It is a known human skin toxicant, allergen and possible eye irritant⁸⁰. It is also a formaldehyde-releasing preservative, and formaldehyde is known human carcinogen (IARC).

STYRENE

COPOLYMERS

Styrene acrylates copolymer and related styrene-based polymers are most often

found in nail polish, sunscreen (SPF greater than 30), sunscreen moisturizers, body wash/cleansers, shampoos and eyeliners. These products can be contaminated with styrene which is possible human carcinogen².

The European Commission on Endocrine Disruption classifies styrene as a Category 1 endocrine disruptor⁸¹. Short-term exposure to styrene in humans results in mucous membrane and eye irritation, and adverse gastrointestinal effects. Long-term exposure can cause headache, fatigue, weakness, depression, CSN dysfunction, hearing loss, and nerve damage^{82, 83}.

RESORCINOL

Resorcinol is commonly used in hair dyes and acne medication. In higher doses it is toxic and can disrupt the function of the central nervous system (convulsions are reported in acute intoxication) and lead to respiratory problems (respiratory failure in acute intoxication). It has also been shown that resorcinol can disrupt the thyroid function. It has been shown to have two different effects: the inhibition of enzymes involved in thyroid hormone synthesis (leading to hypothyroidism) and the activation of thyroid hormone receptors².

A study of resorcinol's effects on cells, suggests that resorcinol acts like thyroid hormone and as an agonist at thyroid hormone receptors at low doses⁸⁴.

RETINOL

Retinol is the chemical name of the essential micronutrient vitamin A that can be found in anti-aging creams and lotions, moisturizers, and foundation².

Retinoic acid and retinyl palmitate, in combination with sunlight, may increase skin cancer risk⁸⁵. The California EPA's Proposition 65 list identifies all-trans retinoic acid as a developmental toxicant².

SYNTHETIC MUSKS

Synthetic musks can be found in perfumes, colognes, and scented soaps, body wash, sprays, lotions, hair products, detergents, and softeners².

Musk ketone, galaxolide and tonalide alter estrogen activity. Both tonalide and galaxolide inhibit androgen and progesterone from binding to their receptors^{86, 87}. Musk ketone, musk xylene, and tonalide have also increased the growth and multiplication of estrogen-responsive human breast cells⁸⁸.

High levels of musk xylene and musk ketone in women's blood may be associated with gynecological

abnormalities such as ovarian failure and infertility⁸⁹.

TALC

Talc is found in baby powder, body and shower products, lotions, feminine hygiene products, eyeshadow, foundation, lipstick, deodorants and face masks. Some talc may contain the known human carcinogen asbestos that can cause mesothelioma. IARC classified perineal use of talc as possibly carcinogenic (it might be associated with endometrial and ovarian cancer^{2, 90}).

TITANIUM DIOXIDE

Titanium dioxide is used in a variety of personal care products, including sunscreens, pressed powders, and loose powders, as an UV filter or whitening agent. Inhalable titanium dioxide (in powders) is considered to be possible human carcinogen by IARC².

TOLUENE

Toluene is a toxic chemical used in nail products and hair dyes. Exposure to toluene can result in temporary effects such as headaches, dizziness and cracked skin, as well as more serious effects such as reproductive damage and respiratory complications^{2, 91}.

TRICLOSAN

Triclosan and triclocarban are commonly used antimicrobial agents found in antibacterial soaps and detergents, toothpaste and tooth whitening products, antiperspirants, deodorants, shaving products, creams, and color cosmetics².

A 2009 study found that triclosan decreased thyroid hormone concentrations⁹². Another study showed that triclosan enhanced the expression of androgen and estrogen sensitive genes⁹³.

There is also some evidence linking the use of triclosan with the promotion of bacteria that are resistant to antibiotic medications and antibacterial products^{94, 95}.

CONCLUSION

There is a need for the establishment of higher standards in cosmetology in a way of raising awareness about toxic chemicals that should be avoided, promoting safety standards and transforming cosmetic industry into safe and non-toxic. The role of toxicology in cosmetic and cosmeceutical industry is to ensure that toxic ingredients are avoided and replaced with less toxic, or even better, non-toxic chemicals. Therefore, I support the campaign for safe cosmetics.

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