Dyes, Minerals, and Vitamins Used in Cosmetics

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Most minerals and vitamins are beneficial when it comes to the improvement of the condition of the skin, hair or nails, and as they are mostly safe for use, they are valued raw materials and cosmetic ingredients. Dyes and pigments, due to the potential negative impact on human health of many of them, are often controversial components of cosmetic preparations. The constantly growing awareness of consumers makes cosmetics manufacturers strive to eliminate potentially harmful substances and use safe raw materials and ingredients of natural origin.

Keywords: cosmetics industry ; beauty ; natural ingredients ; health

1. Introduction

The cosmetics market of the European Union, as well as the world cosmetics market, develop strongly together with consumers' awareness. Producers and consumers are becoming more open to using natural cosmetics. A variety of natural raw materials is used by the cosmetics industry. Consumers more often choose natural or ecological cosmetics, free from preservatives, unnecessary dyes, fragrances, and contaminants. It forces cosmetic manufacturers to constantly improve the safety and quality of cosmetic products [1]. The human body and its proper functioning depend on several dozen chemical elements. The human skin requires about 30 elements for the proper course of its processes [2]. The body itself cannot synthesize them, so they should be taken with food. Scientists try to find ways to provide these essential nutrients other than the food route. Therefore, more and more often, the elements become the active ingredients of creams, masks, and other cosmetic preparations. For example, cosmetics with minerals are part of a new trend in natural cosmetics [1]. The global mineral cosmetics market size was valued at USD 2.05 billion in 2021 and is expected to achieve USD 2.94 billion by 2026 [3]. Clay minerals have exceptional qualities, among others, high bio-compatibility and low or no toxicity. The history of the cosmetic usage of minerals dates back to ancient times [4]. As a result, the manufacturers have been introducing make-up products made of natural minerals, including zinc oxide, iron oxides, titanium dioxide, organic oils, and mica powder [3]. While many other cosmetic active agents experience their ups and downs, vitamins are one of the most commonly used active ingredients, and their role in skin care have been increasing [5]. They are essential components of natural and physiological cosmetics. Moreover, cosmeceuticals rich in vitamins are becoming more and more popular [6]. Vitamins have a positive effect on the condition of the skin and improve its health and appearance. They are invaluable in the fight against the effects of skin aging, support the normalization of disturbed skin balance, and stimulate tissue renewal. Dyes are essential ingredients of cosmetic products and have a long history of usage [7]. They influence consumer senses, increase the quality of cosmetics, and ensure their better functionality; however, many of them are presently considered as controversial cosmetic ingredients. Application of cosmetics compounds include dermal, oral, or ocular routes, depending on the form, physical–chemical properties, and intended use of the product [8]. There are three possible pathways for penetration of cosmetic ingredients through the skin [9]. These are transappendageal penetration through the hair follicle or via the sebaceous and/or sweat glands, intracellular (transcellular) permeation through the corneocytes, and intercellular through the lipid matrix. The intercellular route allows a straight path through the skin into the lower levels of the epidermis and the dermis.

2. Minerals

In the production of cosmetics, many mineral raw materials are used, such as bentonite, kaolin, illite, mica, talc, and others. Their application is directly related to their mineralogical and chemical composition. For example, clays containing high amounts of Si provide tissue hydration and mitigation of possible skin inflammatory processes. Moreover, they can be used in the reconstruction of skin tissues. Aluminum (Al) is another element found in high amounts in clays. Al is relevant in raw materials for cosmetics application due to its healing activity, hydration, dispersion of pigment, and adsorption of melanin. Clays, which contain Si, Al, Ca, Ti, Fe, and K, can be employed for bactericidal, antiseptic, and regenerative action, that contribute to cell renewal, invigoration of tissues, circulation activation, and adsorption of impurities [10]. Clay minerals and clays are extensively used for cosmetic purposes due to their high specific surface area,

optimum rheological characteristics, and excellent ion exchange capability (CEC) [11]. Aluminum clays and minerals can be found in many skin care products, such as creams, but they can be also used separately for pimples and various types of skin rashes [12]. Because of their ion exchange capability, aluminum minerals are used as the active base in face masks. They are recommended for people who struggle with inflammatory skin conditions, such as ulcers and acne. Bentonite massage creams have the ability to open the pores of the skin and facilitate the penetration of active minerals (Cu, Zn, and Hg), which are responsible for the proper course of regenerative processes [13]. However, clay minerals can also have a negative effect on consumer health. For example, in case of inhalation for a very long time they can cause lung cancer, mesothelioma, or pneumoconiosis. The minerals toxicity is generally related to the presence of asbestos or quartz from mining operations [14]. Additionally, heavy metals, such as Sb, As, Cd, Pb, Ni, and Tl, may be present in different minerals and thus cause a risk for human health. These metals are banned by the European Commission, whereas US Food and Drug Administration (FDA) and Canada have established strict limits on their maximum concentration in cosmetics. Face masks and eye cosmetics can facilitate the absorption of metals through the skin. Metals present in cosmetics can also accumulate in the skin. Allergic reactions [15] and internal organs damage (caused by Hg and Pb) were observed as a result of topical and systemic effects of the use of cosmetics containing heavy metals [16]. In general, the use of minerals (mainly in make-up products) is currently one of the basic tendencies when it comes to the use of natural and organic raw materials in the cosmetics industry [1][11][12][17].

3. Vitamins

Vitamins are organic chemical compounds divided into two groups: water-soluble (hydrophilic) and fat-soluble (lipophylic) [18]. The first group includes vitamins B, F, and H, and the second group includes vitamins A, D, E, and K, which are readily absorbed through the skin. The intake and absorption of vitamins and antioxidants with food are of key importance for human health. In the human body, vitamins perform regulatory functions and also affect the health and physical performance of the body. Most of the vitamins are not synthesized in the body; therefore, they must be supplied with food. Besides free vitamins, their derivatives (compounds of vitamins with other substances; acid esters, such as palmitic acid and acetic acid) or provitamins (pre-stages of vitamins) are also assimilated. Thanks to their unique functions, vitamins are used in prophylaxis and in the local and systemic treatment of photoaging, as well as chronological skin aging [19]. The antioxidant properties of vitamins are used in cosmetics for skin, hair, and nails. Water-soluble vitamins are the largest group, and among them, vitamins B, C, and others are the most commonly used in cosmetics [5][6]. In the cosmetics industry, natural vitamins come mostly from raw materials of plant origin, which are used more and more often. Plants contain a number of other biologically active and easily accessible ingredients, such as antioxidants, oils, and others [20]. Vitamins need to be replenished constantly as they use up when they fulfill their respective functions in the human body. This applies not only to the organism as a whole but to the skin in particular.

4. Dyes

Colors play a decisive role in the marketing of cosmetic products. Thousands of substances are used to color the product itself or to color a body part (hair, skin, eyelashes, and nails). Synthetic dyes are the most widespread in the cosmetics industry. Dyes act on the principle of absorbing and reflecting sunlight [21]. Colorants are divided into two categories in terms of solubility: dyes and pigments. Dyes are made up of synthetic organic compounds and are hydro or oil-soluble. They may be present in skin care products and toiletries. Pigments, on the other hand, are insoluble and remain in particulate form. They are found mainly in toothpaste and decorative make-up [22]. Dyes can be classified according to chemical structure in five main groups: azoic, triarylmethane, xanthenes, indigoid, and quinoline. Each coloring agent used in the cosmetics industry is marked with the symbol C.I. (Color Index) followed by the number of the given dye. There are a number of dyes that are restricted or banned in the European Union [23] and cannot be used in products applied on mucous membranes or in eye products. The maximum concentration of many dyes in ready-for-use preparations may not exceed a few percent.

Some of the dyes present in cosmetic products can cause negative health effects. Dermal contact, with special attention to areas close to mucous membranes, is the main route of human exposure to dyes present in cosmetics. For example, the dye CI 17200, which is identified by the FDA code as red No. 33 and assigned to the nitrogen chromophore group [24], can release amines, which are considered to be carcinogenic [25]. The dye CI 19140 (Yellow No. 5, tetrazine), which belongs to the azo chromophore group [22][24], has been limited in the European Union in products for children, because it causes them to be hyperactive, and in hair dye products [23][26]. Tetrazine can also lead to dermatitis, anaphylaxis, and itching of the lips and tongue [27]. CI 47005 (Yellow No. 10) is assigned to the quinoline chromophore group [24]. This dye can be genotoxic when absorbed through the skin [28]. The dye CI 16255 (red code 4R) belongs to the azo chromophore group [24] and can cause sensitization by itself or in combination with sunset yellow [29]. CI 15985 (Yellow No. 6, orange–

yellow), assigned to the azo chromophore group [24][30], can cause concentration disorders and hyperactivity in children, as well as urticaria, Quincki's edema and allergic reactions that may lead to anaphylaxis [31]. CI 14720 (the trade name Azorubine, according to the Color Index—Food Red3, Acid Red 13) is an azo dye with hepatotoxic properties. It does not exhibit carcinogenic properties but is an inducer of DNA chain damage [32]. The dye CI 16185 (Amaranth [33]) affects the hormonal balance, which is associated with adverse health effects [34][35]. The dye CI 75810 is assigned to the chlorophyll group and defined by the FDA code as chlorophyllin [24]. This dye is used mostly in the food industry but is also used in the cosmetics industry for its antioxidant, anti-inflammatory, and wound-healing effects. It is used in photoprotective preparations because it influences the treatment of photodamage [36]. CI 77891 (White Color No. 6) belongs to the chemical class TiO_2 Azocompound [37]. It is used in the production of toothpaste as a whitening agent. The dye improperly ground in cosmetics causes whitening of the skin and is susceptible to abrasion, which is not conducive to providing protection against harmful factors of ultraviolet radiation. Its too small fragmentation causes the deeper penetration of the product with this dye into the skin, thus increasing the toxicity of the preparations [38]. The dye CI 60730 (Acid Violet 43) is prohibited for use in eye products and in cosmetics that come into contact with mucous membranes [23][21]. The dye CI 45100 (acid red, or Acid Red 33) is mildly allergic [39].

5. Conclusions

The safety of cosmetics usage is very important. Some minerals used in cosmetics may negatively affect human health, for example, due to the content of heavy metals, which presence in cosmetics is not banned in many countries. In recent years, the safety of using talcum powder and mica in cosmetics and care products has been particularly discussed. Most minerals and vitamins are beneficial when it comes to the improvement of the condition of the skin, hair, or nails, and as they are mostly safe for use, they are valued raw materials and cosmetic ingredients. Dyes, due to the potential negative impact on human health of many of them, are often controversial components of cosmetic preparations. The constantly growing awareness of consumers makes cosmetics manufacturers strive to eliminate potentially harmful substances and use safe raw materials and ingredients of natural origin. Therefore, there is a need for further studies on the possible negative effects of dyes, minerals, and vitamins used in cosmetic products, as well as updating the legal provisions on their use.

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