

Heavy Metal Contamination of Popular Nail Polishes in Iran

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ABSTRACT

Background: Toxic and hazardous heavy metals like arsenic, lead, mercury, zinc, chromium and iron are found in a variety of personal care products, e.g. lipstick, whitening toothpaste, eyeliner and nail color. The nails absorb the pigments of nail polishes and vaporized or soluble metals can easily pass it. The goal of this survey was to assess whether the different colors of nail polishes comply with maximum concentrations of heavy metals in the EPA's guidelines.

Methods: 150 samples of different popular brands of nail polishes in 13 colors (yellow, beige, silver, pink, white, violet, brown, golden, green, black, colorless, red and blue) were randomly purchased from beauty shops in Tehran City, Iran, in 2014. Microwave digestion EPA method 3051 was used by a microwave oven to determine the amount of 5 heavy metals; Nickel, Chromium, Lead, Arsenic and Cadmium. One-way ANOVA, Two-way ANOVA, hierarchical cluster, and principal component analyses were applied by Statistica 7.0 software.

Results: The concentrations of chrome, lead, nickel and arsenic showed significant differences between the colors ($p < 0.05$). In all studied samples, the level of cadmium was beyond the safe maximum permissible limit (MPS), but no significance difference in the cadmium content was identified.

Conclusion: Due to the high concentrations of toxic metals in many brands of nail polishes, meticulous quality control is recommended for these beauty products.

Keywords: Arsenic; Cadmium; Chromium; Cosmetics; Lead; Nickel.

INTRODUCTION

Declaring the color additives and ingredients on cosmetic product labels had been a major concern of toxicologists for many years. Some studies claim that cosmetics are one of the major sources of releasing heavy metals in the environment [1]. Toxic and hazardous heavy metals like arsenic, lead, mercury, zinc, chromium and iron are found in a variety of personal care products, e.g. lipstick, whitening toothpaste, eyeliner and nail color. Some heavy metals are used in the cosmetics as ingredients, while most of others are contaminants [2]. In recent years, the threat of existing contaminants and their concentration in human body to health have become an important concern and cosmetics, disinfectants and other personal body care products were most focused as major sources of releasing heavy metals to human systems [3-8].

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The human nail is more permeable than skin and it consists of 10-30% water. The nails absorb the pigments of nail polishes [9] and vaporized or soluble metals can easily pass it. FDA (Food & Drug Association of United States) have introduced some admissible pigments for using as additive color ingredients in cosmetics and all other components must go for pre-market approval before could be applied in any cosmetics [10, 11]. The maximum permissible level for lead and arsenic has been fixed for synthetic and natural organic colors in Drugs and Cosmetics Rules since 1945, while no limitation has been settled for inorganic colors, yet. FDA has fixed a limit for lead in candy (0.1ppm) while there is no limit set for heavy metals in cosmetic products such as lipstick and nail polishes [12]. The term "ingredient" has not been defined under Drugs and Cosmetics Act for cosmetics. For colorants to be treated as an ingredient the term needs to be suitably defined

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and requirements of colorants required to be mentioned in the Drugs and Cosmetics Act. No guideline has been provided by the Drugs & Cosmetics Act and Rules that indexes coloring agents of cosmetics.

Since 1940s, scientists have known that nail polishes contain allergenic ingredients [13]. Heavy metals like lead and cadmium are common contaminant in various cosmetic products [10, 14, 15]. Heavy metal toxicity can result in damage to mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver and other vital organs. Long-term exposure may result in slowly progressing physical, muscular and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis. Allergies are common and long-term contact with some heavy metals may even cause cancer [16, 17].

The possibility of skin allergy and contact dermatitis may increase due to the presence of heavy metals in cosmetics. Arsenic has pronounced affinity for skin and keratinized structures, e.g. hair and nails, and can cause a variety of skin eruptions, alopecia and characteristic striation of the nails [18-20]. Arsenic, cadmium and their inorganic compounds are considered as human carcinogens [21]. Maximum acceptable concentration (MAC) of arsenic in drinking water is 0.01mg/l (10µg/l=10ppb) in Canada [22]. Acceptable limits of oral ingestion of arsenic is 0.1ppm in foods [22] and 3ppm in nutritional supplements (USP). FDA limit for arsenic in certain colorants is <3ppm [23].

Today, a wide range of formulations for nail polishes is available. Current trends include nail polish strips, gel nails, water-based nail polish, textured nails, color changing nail polish with countless novel colors and textures are introduced each day. Iranian, Arab, and Turkish women traditionally use more cosmetics than women in western countries. The Persian culture has had a strong emphasis on beauty, aesthetics,

art, fashion, design and poetry more than any other countries in the Middle East. After the beauty revolution in the West from 1920s and 30s, cosmetic brands have been imported to Iran and were actively purchased by the Iranian elites. Iran and Saudi Arabia have the highest amount of consumption of cosmetics in the Middle East [24]. Iran is ranked as the seventh largest consumer of cosmetics in the world. Although, Iran has domestic cosmetics industries, the majority of its beauty products are imported from China, Korea and Turkey [25].

Due to the excessive use of cosmetics in Iran and lack of investigation on their safety, the goal of this survey was to assess whether the different colors of nail polishes used in Iran comply with maximum concentrations of five heavy metals (Nickel, Chromium, Lead, Arsenic and Cadmium) in the EPA's guidelines.

MATERIALS AND METHODS

150 samples of different popular brands (Nivea, Golden Rose, Leydi, Top Lady, Golbaran, Jourdana, Prestigue, Max factor, Atoosa, My, Gabrini, Zoya, and Jade) of nail polishes in 13 colors (yellow, beige, silver, pink, white, violet, brown, golden, green, black, colorless, red and blue) made in different countries (Iran, Italy, England, USA, France, China, Germany and Turkey) were randomly purchased from beauty shops in Tehran City, Iran, in 2014. Samples were stored at room temperature before use.

Nail polishes were painted onto tarred weighing paper and allowed to dry before weighing in the digestion vessel. Microwave digestion EPA method 3051 was used by a microwave oven (Multiwave 3000; PerkinElmer, Shelton, CT, USA). 10ml of nitric and 1ml of hydrofluoric acid (Merck; Germany) were added to the vessels with approximately 0.5g of sample utilizing the applied digestion program (Quartz Concentric nebulizer, Quartz Cyclonic Spray Chamber, RF Power of 1500W and 1000ms/per analyte integration time).

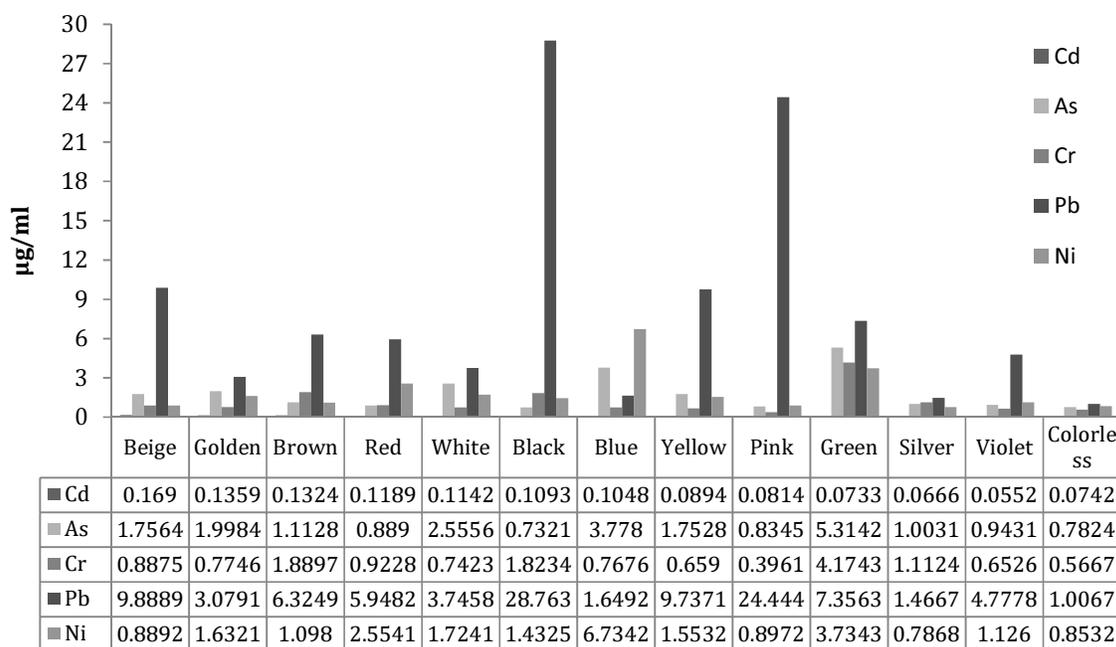


Figure 1. Mean level of nickel (Ni), cadmium (Cd), lead (Pb), chromium (Cr) and arsenic (As) content in nail polish samples.

Samples were then transferred and diluted to 50ml with nitric acid 10% until they became fairly homogeneous. Samples were analyzed based on the amount of sample taken for digestion and the final volume of solution by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method (Varian 730-ES Axial ICP-OES: USA) [26].

Analysis of variance (ANOVA) was performed on each brand of nail polishes to find out if there were significant variations in the concentrations of heavy metals in different colors of each brand. To compare brands and probable ingredient effects on color profiles, Statistica 7.0 software was used. Two-way ANOVA, hierarchical cluster, and principal component analyses were applied. Results were determined as Mean($\mu\text{g/g}$) \pm SE or Mean($\mu\text{g/ml}$) \pm SE from three replicates in each test.

RESULTS

The level of nickel was ranged from 1.22 to 6.73 $\mu\text{g/g}$ in different samples. There was a significant difference in the levels of nickel in 13 colors and in the blue had significantly ($p < 0.01$)

much more nickel content than other colors (Figure 1).

The level of cadmium was ranged from 0.0472 to 0.7321 $\mu\text{g/g}$ in different samples. In all studied samples, the level of cadmium was beyond the safe maximum permissible limit (MPS), but no significance difference in the cadmium content was identified (Figure 1). Beige color samples had the highest levels of cadmium, while all colorless nail polishes had the lowest content.

The level of lead was ranged from 1.0067 to 33.7820 $\mu\text{g/g}$ in different samples. Black and pink had significantly ($p < 0.05$) higher levels of lead than other colors (Figure 1).

The level of chrome was ranged from 0.3961 to 4.1743 $\mu\text{g/g}$ in different samples. There was a significant ($p < 0.05$) difference in the levels of chromium in green color (Figure 1).

The level of arsenic was ranged from 0.23 to 5.89 $\mu\text{g/g}$ in different samples. The arsenic level was significantly higher in green materials (Figure 1).

DISCUSSION

All the nail polishes monitored in this study contained detectable amounts of heavy

metals. FDA has not set limits for metals in cosmetics, except for zirconium, which is prohibited in aerosol preparations, and mercury that can only be used (generally as a preservative) when no other alternative is possible. Regulations in Canada include statements about heavy metals, and the maximum permissible limits (MPS) of cadmium, lead and chromium were established at 3, 10, and 3ppm, respectively [27].

In brands like Top Lady, Leydi and some fake Chinese brands, there was significant difference in the levels of lead between analyzed colors. Black in all brands had the highest concentration of lead, while silver, blue and colorless polishes had the lowest lead content. The highest concentrations of lead and cadmium were detected in Chinese cheap samples. The mean content of lead in 57.8% of the 53 Chinese samples was much higher than 20µg/ml and the maximum level (198.6µg/ml) was found in black color. According to proposed limits of metals in cosmetics set by Canada Health Center in 2009 [28, 29], 14.2% of Iranian, 5.3% of Turkish, 3.8% of Italian and 1.5% of American samples were contaminated with lead.

In 8 of 15 green samples the Cr content was much higher than the other groups ($p < 0.01$) and in 5 brands, Ni content was significantly higher ($p < 0.005$). This result reveals that the type of pigment used in nail polish ingredient contributes to its heavy metal content. Chromium VI compounds are toxins and known human carcinogens, whereas Chromium III is an essential nutrient. Inhaling high amounts of chromium can cause irritation to the lining of the nose, asthma and shortness of breath or wheezing and skin contact can result in skin ulcers. Allergic reactions consisting of severe redness and swelling of the skin have been reported due to chromium exposure. Long-term exposure can cause damage to the liver, kidneys, heart, circulatory system and nerve tissues, as well as skin irritation and decreased body weight [7]. Short-term overexposure to nickel has not been reported to cause any problems. The EPA

does not currently regulate nickel levels in drinking water [7].

In an Iranian brand (Golbaran), the mean content of lead in black and beige colors was higher than the 20mg/kg, which is established as the maximal lead limit in impurities in cosmetics color additives following the good manufacturing practices, while in Atoosa brand no contamination was identified. Arsenic content in green and blue colors were significantly higher than other colors in cheap Chinese samples. Arsenic was not present in any European and American studied samples. The arsenic concentration in cheap green samples was about 2.5 times of the concentrations in the white and about 5 times greater than silver, violet, colorless, red and brown samples.

Heavy metals in nail polish products may harm consumers. Toxic metals especially arsenic, lead and chromium in nail polishes and other cosmetics like eye shadows and lipsticks can accumulate in body over time with repetitive application. Previous studies on lipsticks and eye shadows purchased from Tehran markets in Iran revealed that 95.9% of Chinese lipsticks and 66.6% of eye shadows had high levels of lead [10, 24]. As lead, nickel and arsenic are not usual ingredients of lipstick, eye shadow and nail polishes, they might have been present as impurities in the color additives. Therefore, meticulous quality control is recommended for beauty products, as the skin and nail tissues can absorb these heavy metals. Assessment of dermal absorption of a single component in a cosmetic product is a complex issue and depends on various factors such as the concentration in the product, the amount of product applied, the length of time left on the skin and the presence of emollients and/or penetration enhancers in the cosmetic product; therefore, more studies are recommended. Manufacturers ought to assess raw ingredients before adding them to the final products. The ingredients should not be recycled or residual byproducts of other industrial processes or contain impurities. The international cooperation between toxicologists

and manufacturers of beauty products can reduce the risk of toxicity by heavy metals for consumers.

CONCLUSION

Due to the high concentrations of toxic metals in many brands of nail polishes, meticulous quality control is recommended for these beauty products.

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