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Full Length Research Paper

Evaluation of the concentration of toxic metals in cosmetic products in Nigeria

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It has been shown that heavy metals toxicity to humans is as a result of long term or high level exposure to pollutants common in the environment including the air, water, food and numerous consumer products such as the cosmetics and toiletries. In this study, we assessed the levels of toxic metals in different cosmetic products sold at local shops in Lagos, Nigeria. The cosmetic items included thirty creams and twenty lipsticks and lip glosses. These items were purchased from various shops at different locations in Lagos. The cosmetics were analyzed for heavy metals (arsenic, cadmium, lead, mercury and nickel) after digestion with concentrated acids HNO_3: H_2SO_4: $HClO_4$ in ratio 2:2:1. The concentrations of the selected toxic heavy metals were determined in duplicate using a Buck 205 flame atomic absorption spectrophotometer. All the samples analyzed contained a detectable amount of all the metals of interest. The concentration of the heavy metals in the samples ranged from 0.006 to 0.207 ppm. It is obvious from the present study that the use of some cosmetic products exposes users to low concentrations of toxic heavy metals which could constitute potential health risk to users since it has been known that heavy metals can accumulate in the biological system over time and are known to induce skin problems or diseases such as cancer. Further research to better understand the sources of heavy metals in cosmetic products is recommended.

Key words: Toxic heavy metals, cosmetics, atomic absorption spectrophotometer, environment.

INTRODUCTION

A cosmetic product is any substance or preparation intended to be placed in contact with the various external parts of the human body (epidermis, hair system, nails, lips and external genital organs) or applied to the teeth and the mucous membranes of the oral cavity with a view exclusively or mainly for the purpose of cleaning, perfuming, protection, changing their appearance, correcting body odours and keeping the surfaces in good condition (Reed, 2007; Oyedeji et al., 2011).

Cosmetics are mixtures of some surfactants, oils and other ingredients and are required to be effective, long-lasting, stable and safe to human use (Rao and Prathiba, 1998).

The various forms of cosmetic include lipstick and lip gloss (used to colour the lips); powder, and rouge (used to colour the face, lightening and removing flaws to produce an impression of health and youth); mascara (used to enhance the eye lashes, eye liner and eye shadow (used to colour the eye lids); and nail polish (used to colour the fingernails and toenails) (Reed, 2007).

There is a general belief that even with the regulation of many cosmetic products, there are still health concerns regarding the presence of harmful chemicals within these products. Aside from colour additives, cosmetic products and their ingredients are not subject to Food and Drug Administration (FDA) regulation prior to their release into the market. It is only when a product is found to violate Federal Food, Drug, and Cosmetic Act (FD&C Act) and Fair Packaging and Labeling Act (FPLA) after its release that the FDA may start taking action against this violation. With many new products released into the market every

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season, it is hard to keep track of the safety of every product and some products may carry carcinogenic contaminant (Peter and Viraraghavan, 2005).

Acceptable limits for heavy metals vary according to the subpopulation of interest (for example, children are more susceptible to heavy metal toxicity than adults). Assessment of dermal absorption by a single component in a cosmetic product is complex and depends on 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 penetration enhancers in the cosmetic product. Given this complexity and the lack of well-conducted dermal absorption studies incorporating these factors, determination of heavy metal limits in cosmetics based on human health risk alone is a challenge (Peter & Viraraghavan, 2005; Oyedeji et al., 2011).

It was disclosed in a report that 100% of all cosmetics product tested positive for nickel and over 90% tested positive for both lead and beryllium (Health Canada, 2011). The products, on average, contained at least 4 of the 8 metals of concern (arsenic, cadmium, lead, mercury, beryllium, nickel, selenium and thallium). Highest levels of arsenic (70 ppm), cadmium (3 ppm) and lead (110 ppm) were found in lip glosses that are often ingested while being worn (Health Canada, 2011). Heavy metals are found naturally in the environment in rocks, soil and water; therefore they exist in the manufacture of pigments and other raw materials in all industries including the cosmetics industry. Some of these metals have been used as cosmetic ingredients in the past. Examples include the preservative thiomersal (mercury), the progressive hair dye lead acetate and a number of tattoo pigments such as red cinnabar (mercuric sulfide).

Since the issue of heavy metals as deliberate cosmetic ingredients have been addressed, attention is turned to the presence of these substances as impurities. The metals of primary toxicological concern in cosmetics are lead, arsenic, cadmium, mercury and antimony (Sainio et al., 2000). Dermal exposure is expected to be the most significant route for cosmetic products since the majority of cosmetics are applied to the skin. Dermal absorption of heavy metals is fairly minimal, with absorption of individual elements influenced by a number of factors including physical-chemical properties of the mixtures. Oral exposure can occur for cosmetics used in and around the mouth as well as from hand-to-mouth contact after exposure to cosmetics containing heavy metal impurities. However, inhalation exposure is typically considered to be negligible (Sainio et al., 2000).

At higher concentrations, heavy metals have been shown to have negative effects. Cancerous breast biopsies show higher accumulations of nickel, chromium, cadmium, mercury and lead than non-cancerous biopsies and several metals act like estrogen in the presence of some breast cancer cells. Lead, which may be an impurity, is a proven neurotoxinlinked to learning, language and behavioral problems. It has also been linked to miscarriage, reduced fertility in men and women, hormonal changes, menstrual irregularities and delays in puberty onset in girls. At puberty, boys developing testes may be particularly vulnerable to lead. Pregnant women and young children are also vulnerable because lead crosses the placenta and may enter the fetal brain (Horowitz et al., 2002). Mercury is linked to nervous system toxicity, as well as reproductive, immune and respiratory toxicity. Mercury is also found in thiomersal, which is a mercury-based preservative. Mercury is particularly hazardous during foetal development and is readily absorbed by the skin. Neither mercury nor thiomersal are highly common as direct ingredients or impurities, but the high toxicity of this metal means that the presence of mercury in any cosmetic is a concern. Other heavy metals show a similar tendency to be toxic (Horowitz et al., 2002).

The aim of this study was to determine the concentrations of toxic metals in cosmetics sold in different shops in Lagos Nigeria with a view of assessing the potential risks that such cosmetic may pose to consumers.

MATERIALS AND METHODS

Sample collection

Fifty cosmetics in the form of lipsticks, lip glosses and skin whitening creams (in tubes, cups and bottles) were bought from various stores and shops in different locations in Lagos, Nigeria.

Preparation of standard solutions

Standard solutions of lead, cadmium, arsenic, mercury and nickel were prepared from 1000 ppm Standard Stock Solution of GFS Fishers' AAS Reference Standard. These stock solutions were serially diluted to give concentrations of 0, 0.5, 1, 1.5 and 2 ppm for arsenic and mercury standards while 0, 2, 4, 6, and 8 ppm for lead, cadmium and nickel standards, respectively.

Preparation/digestion of samples

All the samples were digested using the same method (Welz and Sperling, 1999). The creams were emptied into a clean beaker and transferred to a homogenizer. It was homogenized for 10mins at 1000 rpm (for solid samples like the lipstick, it was first crushed in an agate mortar before homogenization). 5 ml of each sample was carefully pipetted into digestion test tubes in a digestion rack and 25 ml of the digested acid (2:2:1 HNO_3: H_2SO_4: $HClO_4$) was added to each sample. This was placed on the digester inside the fume cupboard. On completion of digestion, the digested samples were allowed to cool to room temperature and made up to 50mls with distilled water. The samples were transferred into centrifuge tubes, shook in a mechanical shaker for 10 min at 1500 rpm and then centrifuged for 5 min at 5000 rpm to allow the particles to settle. 25 ml supernatant of each sample was transferred into pyrex vials for analysis.

Sample analysis

The most frequently used analytical method for the analysis of heavy metal contamination in most cosmetic products is atomic

Table 1. Regression data for the analysis of the standard solutions.

Metal	Arsenic	Cadmium	Lead	Mercury	Nickel
Regression equation	y = 0.2x + 0.0001	y = 0.252x – 0.004	y = 0.100x – 0.000	y = 0.200x + 0.000	y = 0.1x
Coefficient of determination (R^2)	1.000	0.999	1.0000	1.000	1.000
Pearson's correlation coefficient (r)	1.000	0.999	0.999	1.000	1.000

absorption spectroscopy (AAS) and this method was applied in the analysis of lead, nickel and cadmium. However, for arsenic, hydride generator was attached to AAS for its estimation, while cold vapour technique attached to AAS was used to estimate mercury in this study (Poppiti and Charles, 1994). The calibration plot method was used for analysis. For each element, the instrument was auto-zeroed using the blank (ultra pure water) after which the standard was aspirated into the flame from the lowest to the highest concentration. The corresponding absorbance was obtained by the instrument and the graph of absorbance against concentration was plotted. The samples were analyzed in duplicates with the concentration of the metals present being displayed in parts per million (ppm) by the instrument after extrapolation from the standard curve.

RESULTS

Regression data for the standard calibration plots

The following regression equations, pearson's correlation coefficients and coefficient of determinations were obtained for each calibration plot (Table 1).

Determined metal concentration in each cosmetic

The spectrophotometer automatically determined the concentration of each metal present in the samples by extrapolating the calibration curve in parts per million (Table 2). The analysis was carried out in duplicates and average value was used for statistical analysis.

DISCUSSION

Cosmetics are seen as one of the most important sources of releasing heavy metals into the environment and the human biological system. Following such observation, there is an increasing need to investigate the concentration of toxic metals in some commonly used cosmetic products. It is known for instance that high doses of arsenic can be deadly and that even long-term exposure to low levels of arsenic can cause certain cancers. There is also a growing concern about the physiological and behavioural effects of toxic metals on human population in general. For instance, the toxicity of lead at high concentrations of exposure is well documented but a major concern in recent time is the possibility that continual exposure to even relatively low levels of these toxic metals in cosmetic products may pose potential health risks (Koller et al., 2004). The possibility of skin allergy and contact dermatitis may increase due to the presence of heavy metals in cosmetics. In this study, the different cosmetic products were tested for the presence of arsenic, cadmium, lead, mercury and nickel. Table 3 shows the concentrations of heavy metal for each of the cosmetic samples in ppm.

The heavy metals found in the products tested are categorized as unintentional contaminants. These metals are not intentionally added to the formulation but are simply impurities in the product and are therefore not required to be listed on the labels. An impurity is a substance not intentionally added to a product, but rather is either a byproduct of the manufacturing process, formed by the breakdown of ingredients, or an environmental contaminant of raw ingredients (Ayenimo et al., 2010). The latter is the case for heavy metals, as their persistence in the environment and their natural presence in rocks, soil, and water cause them to be present in the manufacture of pigments and other raw materials used in various industries, including cosmetics. Manufacturers are required to take care to remove these impurities, but time is money and since guidelines are so laid-back, only very few manufacturers remove these heavy metals from the final product (Health Canada, 2011). Although the presence of the toxic metals in all the samples were in trace amount, 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. It has been reported that these metals interfere with essential nutrients of similar oxidation states such as calcium and zinc (Adepoju-Bello and Alabi, 2005). It has been observed that mercury is used in skin whiteners because the metal blocks production of melanin, which gives hair and skins their pigmentation. It has been noted that although other chemicals can achieve the same purpose but because mercury is inexpensive and effective, manufacturers prefer using it and this may explain the relatively high amount of mercury detected in White Caris lotion and tenovate gel in this study. Mercury is toxic and rapidly absorbed through the skin and can affect people neurologically, causing blurred vision or trouble walking. Severe mercury poisoning can shut down organs and lead to death. The use of mercury in skin creams have been well-documented in other countries and should be of concern to the FDA (US Food & Drug Administration, 2010).

Metals are well-recognized because of allergic contact dermatitis (ACD) both at occupational and environmental levels and nickel is considered the primary source in causing ACD with a prevalence of 20% in females and

Table 2. Concentration of heavy metals in cosmetic samples in Nigeria.

Sample	Avg. conc. As (ppm)	Avg. conc. of Cd (ppm)	Avg. conc. of Pb (ppm)	Avg. conc. of Hg (ppm)	Avg. conc. of Ni (ppm)
C1	0.016	0.041	0.032	0.009	0.049
C2	0.013	0.037	0.045	0.020	0.060
C3	0.014	0.034	0.023	0.020	0.040
C4	0.019	0.073	0.048	0.010	0.065
C5	0.006	0.044	0.040	0.010	0.057
C6	0.013	0.065	0.018	0.017	0.036
C7	0.014	0.047	0.029	0.015	0.047
C8	0.013	0.047	0.031	0.035	0.049
C9	0.016	0.048	0.030	0.021	0.048
C10	0.015	0.049	0.028	0.026	0.046
C11	0.014	0.055	0.027	0.024	0.044
C12	0.013	0.053	0.018	0.027	0.035
C13	0.013	0.045	0.020	0.018	0.038
C14	0.013	0.055	0.030	0.017	0.041
C15	0.012	0.098	0.026	0.172	0.043
C16	0.017	0.054	0.030	0.012	0.038
C17	0.017	0.044	0.018	0.022	0.036
C18	0.014	0.073	0.030	0.018	0.039
C19	0.015	0.043	0.032	0.020	0.047
C20	0.006	0.042	0.030	0.028	0.042
C21	0.016	0.029	0.030	0.027	0.039
C22	0.016	0.059	0.030	0.018	0.044
C23	0.013	0.045	0.031	0.028	0.045
C24	0.016	0.041	0.032	0.040	0.047
C25	0.014	0.060	0.028	0.019	0.043
C26	0.013	0.042	0.030	0.019	0.045
C27	0.014	0.056	0.021	0.036	0.036
C28	0.013	0.046	0.040	0.039	0.048
C29	0.013	0.062	0.030	0.032	0.045
C30	0.013	0.070	0.060	0.162	0.069
C31	0.013	0.062	0.031	0.049	0.046
C32	0.013	0.041	0.031	0.045	0.046
C33	0.013	0.053	0.030	0.051	0.045
C34	0.013	0.059	0.031	0.025	0.046
C35	0.008	0.040	0.030	0.030	0.045
C36	0.013	0.048	0.030	0.043	0.045
C37	0.012	0.050	0.028	0.043	0.043
C38	0.019	0.054	0.028	0.037	0.043
C39	0.016	0.030	0.035	0.015	0.050
C40	0.013	0.043	0.029	0.040	0.044
C41	0.015	0.043	0.036	0.028	0.051
C42	0.012	0.026	0.017	0.037	0.032
C43	0.013	0.023	0.031	0.026	0.046
C44	0.015	0.058	0.029	0.022	0.047
C45	0.031	0.203	0.090	0.207	0.105
C46	0.014	0.031	0.040	0.029	0.049
C47	0.012	0.048	0.028	0.023	0.043
C48	0.012	0.028	0.026	0.054	0.041
C49	0.012	0.052	0.032	0.010	0.046
C50	0.009	0.054	0.030	0.018	0.044

1% in males (Josefson et al., 2006). Sensitive people may have a skin rash return if they later ingest nickel. Even if Ni actually represents the main cause of contact dermatitis, minimal amounts of other toxic metals can trigger a pre-existing allergy and reactions to Ni have been associated with lead sensitivity (Bocca et al., 2007). A child was reported to have died of heart failure after accidentally eating 20,360 ppm a nickel compound and workers drinking nickel contaminated-water from a fountain (250 ppm) had stomach aches, increased number of red blood cells, and kidney damage (US Food and Drug Administration, 2010).

Table 3. Summary of statistics of metal analysis.

Parameter	As	Cd	Pb	Hg	Ni
Number of samples	50	50	50	50	50
Number of samples with detectable metal	50	50	50	50	50
% of samples with detectable metal	100%	100%	100%	100%	100%
Minimum conc. of metal ion detected (ppm)	0.006	0.023	0.017	0.009	0.032
Maximum conc. of metal ion detected (ppm)	0.031	0.203	0.090	0.207	0.105

Lead and cadmium are two potentially harmful metals that have aroused considerable interest. Particularly, lead has been described as the most harmful environmental contaminant to arise in human civilization and has been shown to impair renal, homopoietic and the nervous system with different reports linking it to deficiency in cognitive functioning (Chukwuma, 1997; Nnorom et al., 2005).The presence of lead in cosmetics has also been reported and thus the European Union (EU) law for cosmetic banned lead and lead compounds in cosmetics since 1976 and strict adherence to good quality control is essential in ensuring that lead contamination in cosmetic products is prevented (Amit et al., 2010).

The metals analyzed in this study are not listed as ingredients on any of the products. Due to a lack of manufacturer testing and regulatory oversight, it is possible that the companies are not even aware that the products are contaminated with these toxic metals. These contaminants are likely to have gained entrance into the cosmetic products when poor-quality ingredients are used. Most likely, these toxic metals could have been contaminants from one or more of the inorganic base materials used in the manufacturing processes. Since these toxic metals are found in various environments, manufacturers are advised to test the raw ingredients for the presence of these toxic metals before their products are assembled into final products in order to track the origin of these contaminants.

Conclusion

In the present study, arsenic, cadmium, lead, mercury and nickel were determined in various brand of creams, lipsticks and lip-glosses. From the results, the toxic metals were present in low quantities. It is feared however that the continuous use of cosmetic products contaminated with such heavy metals may however cause slow release of these metals into the human body and cause harmful effects to the consumers over time. Extensive use of such products should be avoided until the situation is adequately addressed.

REFERENCES

Adepoju-Bello AA, Alabi OM (2005). Heavy metals: a review. Nig .J. Pharm. 37:41-45.

Amit SC, Rekha B, Atul KS, Sharad SL, Dinesh K, Chaturvedi, Vinayak ST (2010). Determination of lead and cadmium in cosmetic products. J. Chem. Pharm. Res.2:92-97.

Ayenimo JG, Yusuf AM, Adekunle AS (2010). Heavy metal exposure from personal care products. Bull Environ. Contam. Toxicol. 84(1): 8-14.

Bocca B, Forte G, Petrucci F, Cristaudo A (2007). Levels of nickel and other potentially allergenic metals in Ni-tested commercial body creams. J. Pharm. Biomed. Anal. 44:1197-1202.

Chukwuma C (1997). Environmental lead exposure in Africa Ambio 26:399-403.

Health Canada (2011). Toxic metals found in make-up cosmetics. A report released by Environmental Defence. pp23-26.

Horowitz Y, Greenberg D, Ling G, Lifshitz M, Acrodynia A (2002). A case report of two siblings. Arch Dis Child 86:453-455.

Josefson A, Farm G, Styme B, Meding B (2006). The impact of airway irritating exposure and wet work on subjects.Contact Dermat. 55:286-290.

Koller K, Brown T, Spurgeon A, Levy L (2004). Recent development in low level lead exposure and intellectual impairment in children. Environ. Health. Perspect .112:987-994.

Nnorom IC, Igwe JC, Oji-Nnorom CG (2005). Trace metal contents of facial (make-up) cosmetics commonly used in Nigeria. Afr. J. Biotech. 4:1133-1138.

Oyedeji FO, Hassan GO, Adeleke BB (2011). Hydroquinone and heavy metal levels in cosmetics marketed in Nigeria. Trends Appl. Sci. Res. 6:622-639.

Peter AL, Viraraghavan T (2005). Thallium: a review of public health and environmental concerns. Environ. Int. 31(4), 493-501.

Poppiti JA, Charles, S (1994). Practical techniques for laboratory analysis 2nd edition CRC Press. pp. 123-130.

Rao N, Prathiba S (1998). Cosmetics and personal care products. Elsevier Inc pp. 380-382.

Reed, S (2007). Cosmetics and your health. USA Department of Health and Human Services. pp. 22-25.

US Food and Drug Administration (2010). International cooperation on cosmetic regulation (ICCR). www.fda.gov/cosmetics.

Sainio E, Jolanki R, Hakala E, Kanerva L (2000). Metals and arsenic in eye shadows. Contact Derma. 42:5-10.

Welz B, Sperling M (1999). Atomic absorption spectrometry.Wiley-VCH, Weinheim, Germany. p. 52.