ISSN : 0974-7419 Volume 12 Issue 12

Trade Science Inc.

Analytical CHEMISTRY

An Indian Journal

Full Paper

ACAIJ, 12(12) 2013 [443-448]

Assessment of volatile organic compounds and heavy metals concentrations in some Nigerian-made cosmetics

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ABSTRACT

This study assessed concentrations of volatile organic compounds (VOCs) and heavy metals in twelve (12) cosmetic products: medicated powder; talcum powder brands 1, 2, 3, 4, 5, lipstick bands 1, 2, 3 and nail paint brands 1, 2 and 3 manufactured in Nigeria. Except nail paints 1, 2 and 3 which were acidic, other products were alkaline. None of them had the pH suitable for skin suggesting that they could significantly affect the functions of the skin. Fe, Zn, Cu, Cr, Cd and Pb were present in the products. Their presence especially Cr, Cd and Pb which have no biological uses raises questions about the safety of the products. Formaldehyde, toluene, trichloroethene and tetrachloroethene were all present in the cosmetic products analyzed. High concentrations of formaldehyde and toluene especially in the lipsticks and nail paints call for concern because they are carcinogenic and neurotoxic. There is need to have standards for heavy metals and VOCs in cosmetic products to ascertain their safety.

KEYWORDS

Heavy metals;
VOCs;
Medicated powder;
Nail paint;
Lipstick.

INTRODUCTION

Skin is an effective barrier to the environment and any disturbances to it may lead to various skin problems. Of the products applied to the skin, cosmetics are one. They are used to conceal imperfections such as spots, scars, eye shadows, redness of skin and to promote smoothness and skin clarity. They are also used to protect the skin, making it soft, beautiful, attractive, cleanse and change appearance its appearance[1-3]. They are used by millions of consumers worldwide, cutting across different socio-economic classes. They are made up of mixtures of ingredients such as emulsifiers, preservatives, thickeners, colour, fragrance and pH stabilizers. Undesirable side effects have been noticed to be caused by some of the ingredients used in cosmetics[4]. Various reports have established that heavy metals are present in cosmetics as a result of impurities in the pigments or are introduced by the metallic devices used during their production. Heavy metals and their compounds are water-soluble and sweat can promote their percutaneous absorption[5,6]. Levels of heavy metals such as lead, cadmium, chromium, copper and nickel have been reported in soaps, powders, lipsticks, body

creams and hair creams but nail paints have not been well researched into. Epidemiological studies have linked effects of heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni) and copper (Cu) to mortality, morbidity, haematological disorders and pulmonary edema arising from their toxicity even at low concentrations[4,7]. Various forms of mammalian cancers, respiratory diseases, organ failures, retardation of the intellect, gastrointestinal disorders, diarrhoea, stomatitis, tremor, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia had been traced to heavy metal poisoning[8]. Cadmium has been reported to cause kidney damage and bone degradation because it affects calcium metabolism. Lead has been reported to cause alterations in pregnancy, lactation, delivery of low birth weight and menopause[9,10]. Exposure to chromium has been found to be associated with nasopharyngeal carcinoma[11-13]. Other hazardous compounds which have not been comprehensively reported are volatile organic compounds (VOCs). They may be present in cosmetics and personal care products due to the pigment and the solvents used. VOCs such as tetrachloroethene, trichloroethene, formaldehyde and toluene have many harmful health effects even at low concentrations; affecting different target organs like central nervous systems, respiratory system, liver, kidney, reproductive systems etc.[14]. Some of these compounds are known carcinogens. Exposure to these compounds has been reported to cause aplastic anaemia, leukaemia, irritation of mucous membranes, restlessness, convulsions, excitement, depression, disturbance, headache drowsiness, dizziness, tremor, delirium, ataxia, loss of consciousness and even death due to respiratory failure and central nervous system (CNS) disorder[15,16]. Most regulatory agencies in Nigeria do not have standards for levels of heavy metals and volatile organic compounds in cosmetics despite that their use has been on increase. Some of these cosmetic products are not even certified thus could be another source of hazardous compounds. Skin is the largest organ in human and anything applies on it goes into the bloodstream through permeation. Also, the chemical constituents of personal-care products used commercially and continually have potentials to find their ways into the environment (i.e. local streams, rivers, groundwater and perhaps even foods, as sewage biosolids used as fertilizer), usually by treated and untreated sewage and improper disposal. This has further exacerbated environmental pollution. Thus, this study investigates concentrations of volatile organic compounds and heavy metals in some selected cosmetic products produced in Nigeria as human and environmental health is ultimately tied.

MATERIAL AND METHODS

Sampling

Sixty (60) cosmetic samples commonly used in Nigeria comprising medicated powder, talcum powders, nail paints and lipsticks were used for this study. They were all produced in Nigeria and purchased at a local market in Osogbo, Osun State, Nigeria. Products with different batch numbers and from different manufacturers were used. Medicated powder (white), talcum brands 1, 2 and 3 (purple), talcum brands 4 and 5 (white), lipstick brand 1 (red), lipstick brand 2 (green), lipstick brand 3 (brown), nail paint brand 1 (red), nail paint brand 2 (colourless) and nail paint brand 3 (yellow).

Chemicals

Trioxinitrate (v) acid, hydrogen peroxide, perchloric acid and ethyl alcohol were purchased from BDH Poole, England. Deionized-distilled water was used throughout.

Determination of pH

Method of Hans *et al.*,[2] was used for determining the pH in cosmetic products. Powders were dissolved in deionized-distilled water and nail paints and lipsticks were dissolved in ethyl alcohol. pH of the solutions were taken using Jenway pH meter 3505.

Heavy metal determination

The method of Al-Saleh *et al.*,[6] was used for the digestion of lipstick and nail paint with slight modification. 0.25 g lipstick was reacted with 4:1 mixture of concentrated trioxonitrate (v) acid and perchloric acid, left at room temperature for 4 hours then placed in the oven overnight at 85°C. Thereafter, the sample was allowed to cool to room temperature and 1 ml of 30% hydrogen peroxide was added. The sample solutions were then heated at 85°C for another hour. The clear

supernatant was transferred to sterile bottles and diluted to 10 ml with deionized-distilled water. 0.2g of nail paint was digested following the same method. Heavy metal contents were as expressed in mg/l

The method of Nnorom[4] was used for cosmetic powders digestion. 1 g of each sample was treated with 5ml of 1:1 concentrated trioxonitrate (v) acid, placed on a digestion block, heated to near dryness, and allowed to cool to room temperature. Thereafter, 3ml of 30% hydrogen peroxide was added and the heating continued until near dryness. The solution was allowed to cool, then filtered into a calibrated flask and made up to volume with deionized-distilled water to 50ml. duplicate digestions were done. Portion of these solutions was used for heavy metal analysis using atomic absorption spectrophotometer (AAS) S series 711047v1.22. Triplicate analyses were done for each sample for the determination of zinc (Zn), copper (Cu), iron (Fe), chromium (Cr), cadmium (Cd) and lead (Pb).

Volatile organic compounds determination

Each sample was transferred into 10ml vial borosilicate glass. The vial and its content were stoppered by silicone material. Vial was transferred to the cell of head-space sampler coupled with gas chromatography equipped with flame ionization detector (GC-FID, Hewlett-Packard Model, 501, (USA) for analysis of volatile organic compounds. Samples in the vials were pressurized to transfer the volatile compounds through the connecting tubing to capillary columns in the oven of the GC. An HP-VOC capillary column (25 m x 0.32 µm i.d x 0.12 µm film thickness) was used and carrier gas was ultra-pure hydrogen. The GC oven temperature was set initially to 35°C for 2 min., increasing at a rate of 5°C/min. to 80°C and then holding for 10 min. Detector and injector temperatures were maintained at 300°C. The target VOC species were identified by their individual retention time. Triplicate analyses were done for each sample for concentrations of formaldehyde, toluene, trichloroethene and tetrachloroethene. Analytical and internal standards of VOC standard mixture containing all investigated constituents were prepared and VOC concentrations were determined. Correlation coefficients of the calibration curves plotted ranged between 0.9994 and 0.9998.

RESULTS AND DISCUSSION

pH levels

pH values of cosmetic products used in this study are presented in Figure 1. Medicated powder (8.94±0.005), talcum 1 (8.53±0.1), talcum 2 (8.32±0.21), talcum 3 (8.54±0.15), Talcum 4 (7.04±0.03), talcum 5 (7.12±0.08), Lipstick 1 (7.86±0.01), lipstick 2 (7.62±0.61) and lipstick 3 (7.58±1.03) were alkaline while nail paint 1 (5.44±0.19), nail paint 2(5.09± 1.67) and nail paint 3 (5.23± 0.42) were acidic. Medicated powder was most basic.

Assessment of pH of cosmetic products analyzed in this study showed that nine products were alkaline and three were acidic. Since suitable skin pH is considered to be 6.5, thus, acidic and alkaline nature of the cosmetic products determined in this study may adversely affect skin functions such as its ability to fight bacteria[2].

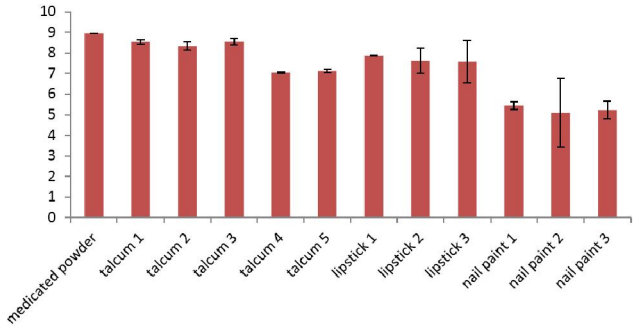

Figure 1 : pH values of different cosmetic products analyzed

Heavy metals concentrations

Concentrations of heavy metals determined are presented in TABLE 1. Medicated powder contained the highest concentration of Zn with 0.452 ±0.018 mg/l and lipstick 3 contained the least concentration of 0.003± 0.001 mg/l. Concentration of Cu was highest in lipstick 1 with 0.495 ± 0.002 mg/l and lowest in nail paint 1 with 0.017 ±0.003 mg/l. Talcum 1has the highest Fe content with 1.604 ±0.043 mg/l while medicated powder has the lowest content with 0.01± 0.001 mg/l. Talcum powder 4 contained the highest content of Cr with 0.206 ± 0.019 mg/l and lipstick 2 has the lowest content with 0.01± 0.001 mg/l. Medicated powder has the highest concentration of Cd with 0.027 ±0.006 mg/l and both talcum 2 and 3 have the lowest contents of

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0.01± 0.001 mg/l. Nail paint 1 has the highest content of Pb with 0.019 ± 0.004 mg/l and medicated powder has the lowest content with 0.004 ± 0.001 mg/l.

All cosmetic products examined contained heavy metals. This reveals that these products could be other sources of heavy metals ingestion and dermal contamination. Their presence might from being used as colourants and as impurities in raw materials due to inadequate purification[4]. The results of heavy metals in this study are lower than what[4,6] obtained for talcum powders and lipsticks respectively. This could be because; some of the samples used by other authors were produced in different countries and industries and are of different brands.

Since these cosmetic products are applied directly on skin and lips, their continuous use may pose significant health threats because studies have shown that heavy metal ions could easily permeate the skin through sweat[1]. Though, Zn is needed in small quantity, its high concentrations recorded in medicated powder, talcum 5 and nail paint 1calls for safety concern because it makes skin unnaturally white and affect pancreas[17]. Fe is equally essential but its high concentrations in the cosmetic products especially in lipstick raises a serious question about the standards followed in producing these items. Various forms of mammalian cancers, respiratory diseases, organ failures and retardation of the intellect, gastrointestinal disorders, diarrhoea, stomatitis, tremor, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia have been traced to heavy metal poisoning[7,8]. Also in lipsticks were highest concentrations of Cu which could get into the blood stream through the lips. Exposure to Cu has been implicated in dermatitis and reported to cause various physiological and behavioural disturbances[8,18]. Cr, Cd and Pb are of no biological value. They are toxic and their presence in these cosmetic products raises safety and health concerns about these items. Cd has been reported to cause kidney damage and bone degradation because it affects calcium metabolism[8,10]. Pb has been reported to cause alterations in pregnancy, lactation, delivery of low birth weight and menopause[5]. Exposure to chromium has been found to be associated with nasopharyngeal carcinoma, exposure[11-13].

TABLE 1 : Concentrations of heavy metal in cosmetics analyzed

Sample	Heavy metals (mg/l)					
	Zn	Cu	Fe	Cr	Cd	Pb
Medicated powder	0.452 ± 0.018	0.022 ± 0.009	0.01 ± 0.001	0.006 ± 0.001	0.027 ± 0.007	0.004 ± 0.001
Talcum 1	0.051 ± 0.021	0.081 ± 0.004	1.604 ± 0.043	0.206 ± 0.019	0.003 ± 0.001	0.01 ± 0.007
Talcum 2	0.103 ± 0.002	0.081 ± 0.003	0.352 ± 0.026	0.014 ± 0.003	0.01 ± 0.001	0.005 ± 0.002
Talcum 3	0.026 ± 0.007	0.093 ± 0.02	0.375 ± 0.192	0.092 ± 0.013	0.01 ± 0.001	0.016 ± 0.008
Talcum 4	0.097 ± 0.005	0.105 ± 0.007	0.061 ± 0.031	0.193 ± 0.004	0.005 ± 0.001	0.013 ± 0.002
Talcum 5	0.318 ± 0.09	0.071 ± 0.003	0.476 ± 0.061	0.015 ± 0.003	0.013 ± 0.002	0.009 ± 0.002
Lipstick 1	0.007 ± 0.002	0.495 ± 0.012	1.014 ± 0.731	0.129 ± 0.005	0.026 ± 0.002	0.007 ± 0.002
Lipstick 2	0.006 ± 0.001	0.329 ± 0.074	0.804 ± 0.019	0.01 ± 0.001	0.003 ± 0.003	0.018 ± 0.005
Lipstick 3	0.003 ± 0.001	0.192 ± 0.065	0.638 ± 0.112	0.031 ± 0.007	0.019 ± 0.004	0.014 ± 0.007
Nail paint 1	0.254 ± 0.03	0.017 ± 0.003	0.576 ± 0.081	0.011 ± 0.002	0.007 ± 0.001	0.019 ± 0.004
Nail paint 2	0.082 ± 0.06	0.029 ± 0.005	0.101 ± 0.007	0.04 ± 0.003	0.012 ± 0.003	0.005 ± 0.001
Nail paint 3	0.077 ± 0.008	0.028 ± 0.002	0.303 ± 0.09	0.12 ± 0.004	0.023 ± 0.006	0.016 ± 0.002

Volatile organic compound concentrations

Concentrations of volatile organic compounds determined in the cosmetic samples are presented in TABLE 2. Concentrations of formaldehyde ranged from 1.36 ± 0.04µg/m3 in medicated powder to 386.79 ± 12.63 µg/m3 in nail paint 3. Trichloroethene concentration was highest in nail paint 3 with 4.54± 1.02 µg/m3 and lowest in talcum 5 with 0.12 ± 0.001 µg/m3. Toluene concentrations ranged from 20.18 ± 5.31µg/m3 in talcum 2 to 679.74 ± 40.72µg/m3 in lipstick 2. Lipstick 2 has the lowest concentration of tetrachloroethene with 0.21 ± 0.03µg/m3 and nail paint 1 has the highest concentration with 0.93 ± 0.04µg/m3. Concentrations of VOCs were generally higher in nail paint and lipsticks compared to powders.

Concentrations of VOCs in cosmetics have not been well reported. Many VOCs are neurotoxins, carcinogens and hormone disruptors[15]. When they are inhaled or applied to the skin, they can cause different arrays of health effects. Most of them are introduced into the products through combination of various chemicals used as solvents, hardeners and colour binders[19,20]. Formaldehyde is used as nail hardener, preservative in powders and to prevent paint from chipping. Its high concentration in these items is untoleratable. Skin exposure to formaldehyde has been shown to cause dermatitis and irritation[20,21]. It is a known carcinogen and its inhalation has been implicated in immune dysfunction, headache, wheezing, coughing and dizziness[22]. Toluene is used as solvent to dissolve other ingredients in cosmetics and to keep colour uniform on the nails. It has been reported to cause anemia, abnormality in babies, lethargy, memory loss and damage to kidneys[15,19,20]. Considering the high levels of toluene found in most of the cosmetics analyzed, and the attendant health implications aforementioned, there is need for the use of safer chemicals as solvents in cosmetic in lieu of toluene. Trichloroethene and tetrachloroethene have no health benefit whereas they have been shown to cause disturbances in central nervous system and changes in parenchyma organs in kidney and liver through dermal absorption[23].

TABLE 2 : Concentrations of volatile organic compounds in Nigerian made cosmetic products

Sample	Volatile Organic Compounds (μg/m^3)			
	Formaldehyde	Trichloroethene	Toluene	Tetrachloroethene
Medicated powder	1.36 ± 0.04	0.78 ± 0.002	65.15 ± 13.02	0.22 ± 0.04
Talcum 1	3.65 ± 0.03	0.74 ± 0.005	32.48 ± 0.94	0.84 ± 0.11
Talcum 2	24.21 ± 3.17	0.25 ± 0.001	20.18 ± 5.31	0.66 ± 0.05
Talcum 3	11.18 ± 0.65	0.85 ± 0.003	96.41 ± 7.45	0.42 ± 0.03
Talcum 4	20.04 ± 1.48	0.76 ± 0.02	27.36 ± 4.06	0.26 ± 0.03
Talcum 5	13.15 ± 1.09	0.12 ± 0.001	62.07 ± 3.11	0.31 ± 0.02
Lipstick 1	97.14 ± 4.52	1.17 ± 0.10	123.64 ± 7.92	0.38 ± 0.05
Lipstick 2	113.87 ± 10.25	1.06 ± 0.04	679.74 ± 40.72	0.21 ± 0.03
Lipstick 3	132.57 ± 16.31	3.07 ± 0.42	372.32 ± 22.04	0.47 ± 0.01
Nail paint 1	167.26 ± 7.01	1.28 ± 0.03	406.78 ± 26.19	0.93 ± 0.04
Nail paint 2	42.19 ± 5.84	1.69 ± 0.07	255.86 ± 38.01	0.87 ± 0.03
Nail paint 3	386.79 ± 12.63	4.54 ± 1.02	283.53 ± 19.15	0.91 ± 0.03

CONCLUSION

Our study has shown that the use of cosmetic products could be another source of exposure to heavy metals and volatile organic compounds which are hazardous, carcinogenic and neurotoxic to our health and the environment. There is therefore need to have standards for the levels of the heavy metals and VOCs in cosmetic products.

CONFLICT OF INTEREST

There is no conflict of interest.

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