Regulatory Toxicology and Pharmacology 83 (2017) 38–45

Contents lists available at ScienceDirect

Regulatory Toxicology and Pharmacology

journal homepage: www.elsevier.com/locate/yrtph

Evaluation of human exposure to metals from some commonly used bathing soaps and shower gels in Nigeria

Chukwujindu M.A. Iwegbue [a, *], Omotekoro S. Emakunu [a], Godwin E. Nwajei [a], Francisca I. Bassey [b], Bice S. Martincigh [c]

[a] Department of Chemistry, Delta State University, P.M.B. 1, Abraka, Delta State, Nigeria
[b] Department of Chemistry, University of Calabar, P.M.B. 1115, Calabar, Cross-River State, Nigeria
[c] School of Chemistry and Physics, University of KwaZulu-Natal, Westville Campus, Private Bag X54001, Durban, 4000, South Africa

ARTICLE INFO

Article history:
Received 13 July 2016
Received in revised form
7 November 2016
Accepted 8 November 2016
Available online 10 November 2016

Keywords:
Metals
Systemic exposure dosage
Margin of safety
Bathing soaps and shower gels
Nigeria

ABSTRACT

The concentrations of nine metals (Cd, Pb, Ni, Cr, Co, Cu, Fe, Mn and Zn) were measured in selected brands of medicated, moisturizing and skin-lightening soaps and shower gels with the aim of evaluating the human health risk associated with metal exposure from the use of these products. The concentrations of metals in these products were determined by means of atomic absorption spectrophotometry after sample digestion with a mixture of acids. The concentration ranges of the metals in the bathing soaps and shower gels were found to be: <0.06–3.4 μg g^{-1} for Cd, <0.09–26.5 μg g^{-1} for Pb, <0.12–43.0 μg g^{-1} for Cr, <0.06–32.5 μg g^{-1} for Ni, <0.06–40.5 μg g^{-1} for Cu, <0.12–8.0 μg g^{-1} for Co, 61.8–4000 μg g^{-1} for Fe, <0.09–29.5 μg g^{-1} for Mn, and 25.5–1000 μg g^{-1} for Zn. The systemic exposure dosage values for these metals obtained from the application of these brands of bathing soaps and shower gels were below their respective provisional tolerable daily intake/or recommended daily intake values. The margin of safety values obtained for the metals were greater than 100 which indicated that there was no significant risk to the users of these brands of bathing soaps and shower gels, except in the case of Co.

1. Introduction

The concentrations of metals in cosmetics and toiletries are of significant health concern because the use of these products represents a potential source of human exposure on a daily basis for a lifetime to metals and other possibly harmful chemicals (Piccinini et al., 2013). Therefore, a more careful and reliable control of the undesirable effects of cosmetics and toiletries is warranted. Human exposure to harmful substances in cosmetics and toiletries occurs mainly through the skin, since the substances may permeate through a number of skin layers and reach the systemic circulation (i.e. blood and lymph vessels) (Gondal et al., 2010). The stratum corneum (SC) is the rate determining layer, and the rate of permeation of a cosmetic substance through the stratum corneum is controlled by a number of factors including the lipophilicity of the compound, the thickness and composition of the SC (which is a function of the body site), exposure duration, the amount of product applied on the skin, the concentration of the target compound, occlusion, etc. (SCCS, 2012). The exposure scenarios vary from one cosmetic product to another; some are applied to restricted areas of the body while some are applied to the entire surface of the body. In addition, some of the products are "leave-on" and may remain in contact with the skin for several hours or days or even weeks (e.g. body cream, nail polishes, deodorants), while others are washed off shortly after application (e.g. soaps, shower gels, toothpaste and shampoos, etc.) (Bocca et al., 2014; Iwegbue, 2015; Iwegbue et al., 2015). Although bathing soaps and shower gels are "washed off" or "rinsed off" they are applied to the entire surface of the skin a number of times per day and for a lifetime, therefore an assessment of possible exposure to contaminants from the use of these products is a worthwhile exercise.

Exposure to trace amounts of metals in cosmetic products and toiletries is of concern because metals can accumulate in the body over time and a number of them are known to cause a variety of chronic health effects including cancer, reproductive, developmental and neurological disorders, contact dermatitis, brittle hair

* Corresponding author.
E-mail addresses: maxipriestley@yahoo.com, jindumax@gmail.com (C.M.A. Iwegbue).

http://dx.doi.org/10.1016/j.yrtph.2016.11.013
0273-2300/

and hair loss (Bocca et al., 2014). Some metals are potent endocrine disruptors and respiratory toxins (Bocca et al., 2014). Moreover, metals such as Cr, Ni and Co are well known skin sensitizers, while Cd, As, Pb, Hg and Sb are exceptionally toxic with many chronic health effects (Forte et al., 2008; Thyssen and Menné, 2010; Bocca et al., 2014). Metals such as As, Cd, Co, Cr, Ni, Pb, Hg and Sb and their compounds are among the 1000 chemicals that are listed as prohibited intentional ingredients of cosmetics in Annex II of the European Council directive 76/768/EEC because they are considered unsafe due to their toxicological properties (Bocca et al., 2014). However, these compounds still persist as impurities in today's cosmetic products due to contamination from the manufacturing process. Despite the high global demand for cosmetic products and toiletries, the safety of their ingredients is one major issue of health concern, and has been of interest to researchers, toxicologists, regulatory agencies, consumer protection groups and other non-governmental organizations, with a common goal to ensure safe levels of the ingredients in the products (Linsey and Milnes, 2011; Al-Saleh and Al-Enazi, 2011; Iwegbue et al., 2015).

The present study examines the concentrations of metals in some bathing soaps and shower gels used in Nigeria with a view to evaluating the risks associated with their use.

2. Materials and methods

2.1. Samples and sample collection

A total of 47 brands were examined, comprising of 34 brands of commonly used soaps and 13 shower gels. The soap types were grouped into (i) moisturizing soaps (11), (ii) medicated soaps (9) and (iii) skin-lightening soaps (14). The samples were carefully selected to reflect the different types used by different income groups. The samples were collected from different cosmetic shops in Abraka, Asaba, Benin City, Warri and Sapele in Nigeria. For each brand, at least three samples with different dates of manufacture and batch numbers were collected in order to study the variations in the elemental composition within a given brand. All samples examined were within their specified usage periods except for one sample. Information on the products investigated is provided in Table 1.

Table 1
Information on medicated, whitening and moisturizing soaps and shower gel samples.

Brand	Colour	Country of Origin
Medicated soaps		
Premier cool	Blue	Ghana
Delta	Blue	Nigeria
Dettol	Pink	UK
Zarina	Grey black	England
BENEK's	Pink	UK
Tetmosol	Yellow	Nigeria
Tura	Blue	Nigeria
Pharmaderm	Green	Cote D'voire
St Luke's prickly heat soap	Lemon	Britain
Whitening soaps		
Skin success	Pink	England
Classic white	White	Nigeria
Bio Claire	Pink	Cote D'voire
Fair & beautiful	Orange	England
Bio tone	Milk	England
Rapid white	Orange	UK
Be white	Brown	England
Skin white	Light pink	Phillipines
Fair & white	Red	France
All clear	Pink	England
Olay soap	White	Toronto, Canada
Idole papaya	Orange	Spain
Fade out	Light brown	Thailand
Beyonce	White	USA
Moisturizing soaps		
Joy	White	Nigeria
Eva Gold	Gold	Nigeria
Harmony Orange	Orange	Indonesia
Harmony Grape	Purple	Indonesia
Dudu osun	Black	Nigeria
Imperial leather	Pink	Ghana
Irish spring	Green	USA
Premier	White	Nigeria
Pears	Brown	USA
Dove	White	Germany
Lux	White	South Africa
Shower gels		
Walch	White	Guangzhou, China
White care	White	Malaysia
Diva maxima	White	Cote D'voire
Olay	White	Toronto
Extreme glow	White	France
Silka skin papaya	Orange	Philippines
Clean & Clear	White	USA
Clearasil skin purifier	Light blue	UK
Tracia	White	Nigeria
Lemon fresh	White	USA
Gentelle	Blue	UK
Fem fresh	Pink	UK
Lovillea	Colourless	Indonesia

2.2. Sample preparation

A mass of 0.5 g of each sample was placed in a digestion tube and 15 mL of a mixture of hydrochloric, nitric and perchloric acids in a ratio of 3:1:1 (by volume) was added. The tube was covered and the sample was predigested for at least 5 h. Thereafter, the mixture was heated to 110 °C in a regulated heating block for 1 h. The digest was allowed to cool to room temperature. It was subsequently reconstituted with 5 mL of 0.25 mol L^{-1} nitric acid, filtered through a Whatman No. 1 filter paper and made up to 25 mL with 0.25 mol L^{-1} nitric acid. Three blanks were prepared by following the entire analytical procedure but omitting the samples.

2.3. Chemical analysis

The concentrations of the nine metals (Cd, Pb, Cr, Ni, Co, Cu, Mn, Zn and Fe) in the sample solutions were analyzed in triplicate by means of atomic absorption spectrophotometry (PerkinElmer Analyst 200, Massachusetts, USA). The calibration standards and blank solutions were analyzed in the same manner as the samples.

2.4. Quality assurance/control

All glassware and sample containers used in this study were thoroughly washed with detergent, rinsed and soaked in 10% nitric acid overnight, and thereafter, rinsed with double distilled and deionized water before use. All samples were analyzed in triplicate; the relative standard deviations of the triplicate analysis were less than 9%. In the absence of a certified reference material, the accuracy of the analytical procedure was validated by using a spike recovery method. This involved the introduction of known amounts of the studied metals at three concentration levels into fresh portions of some of the samples that had been previously analyzed for their metal concentrations, and repeating all the analysis steps from digestion to atomic absorption analysis. The average percentage recoveries for the studied metals were as follows: Cd 93.4%, Pb 89.9%, Cr 96.7%, Ni 94.2%, Co 98.7%, Cu 86.9%, Mn 98.3%, Zn 97.8%, and Fe 101.3%. The r^2 values for the calibration lines ranged from 0.9994 to 1.000. The limits of detection (LODs) of the metals based on a 3:1 signal-to-noise ratio of the blanks were Cd