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Lipsticks and Nail Polishes: Potential Sources of Heavy Metal in Human Body

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Abstract

The concentrations of six heavy metals, Lead (Pb), Nickel (Ni), Cadmium (Cd), Manganese (Mn), Chromium (Cr) and Arsenic (As) were determined using Atomic Absorption Spectrophotometer (AAS) in different color but most popular brand of ten lipsticks and ten nail polishes sold at cosmetic store in Ile- Ife market. Samples dissolution were carried out by wet oxidation methods. The results showed a high metal content in the lipsticks with the range of metals in nail polishes as follows; Pb (< 0.00 − 42.14) µg/ml; Ni (1.88 – 4.22) µg/ml; Cd (5.90 –8.12) µg/ml; Mn (0.76 – 6.32)µg/ml; Cr (1.48 – 3.02) µg/ml and As (0.16 – 0.42)µg/ml. The concentrations in lipstick samples ranges; Pb (15.6 – 124.2) µg/g; Ni (12.2 – 20.4) µg/g; Cd (18.6 – 38.2)µg/g; Manganese (10.4 – 23.4) µg/g; Cr (6.6 – 28.4) µg/g and As (0.8 – 3.0) µg/g. The concentrations were compared with available data on internationally proposed limits for these elements and their possible health implications on the consumering public.

Keywords: *Lipstick, Nail Polishes, Heavy Metals.*

Introduction

The threat of any contaminant to human health is a function of its concentration in the body, in recent times attention had been focused on cosmetics, disinfectants and other personal body care products as major sources of heavy metals in human systems (Ayenimo, 2010 and 2013; Amartey et al., 2011; Onwordi et al.,2011; Khalid et al., 2013) without any information on the levels of heavy metals in the nail polishes. The human nail is permeable than skin and the composition consists of 10% - 30% of water. The nails absorb the pigment in polishes (Rebecca, 2011) and so could enhance easy passage of metal in vapourized form or in solution. The metals in lipstick enroute the mouth and swallowed during eating, while some get to the body through the skin pores, metals in nail polishes reached the body through the porous keratinized nails. The amount that is actually absorbed from the digestive tract can vary widely, depending on the chemical form of the metal and the age and nutritional status of the individual. Once a metal is absorbed, it distributes in tissues and organs. Exposure to heavy metals and metalloids at relatively low levels can cause adverse effects, for example cadmium causes kidney damage and bone degradation. Lead causes mental retardation in children and learning disability. cadmium (Cd) and lead (Pb) often accumulate in the human tissues when they are not metabolized by the body for absorption and utilization (Health Concerns, 2003). Research has shown that lead can cause intrauterine fatal death, premature delivery and low birth weight (ATSDR, 2003 and 2005; Papanikolaou *et al*., 2005; Al-Saleh *et al*., 2009). Research in metal concentration of cosmetics is raising awareness on direct ingestion and skin absorption of metals, since they are daily used and are applied to the thinnest areas of facial skin, such as the pre-ocular areas and lips, where absorption is very high (Corazza et al., 2009). Steinemann (2004) described exposure sciences as the science of identification of a contaminant sources rather than tracing it to the receptor. It is becoming increasingly difficult to avoid exposure to heavy metals because of its prevalence in water , food, air and through skin contact during our daily activities in agricultural, pharmaceutical, industrial or residential settings among others (Ekpo *et al*., 2008). Thus, this study aimed at determining the concentration of metals available in different lipsticks and nail polishes and compare it internationally acceptable limit and highlighting with the possible health implication of its prolong use.

Materials and Methods

Sample Collection and Dissolution

Ten different colored commonly use brands of lipstick and ten nail polishes were bought at cosmetic stores in Ile-Ife main market. They were transported to the laboratory. 0.5g of each of the lipsticks samples were weighed into a teflon beaker, 20 ml of 4:1 HNO_3/ H_2O_2 was added at interval of 3mins repeatedly for ten times using the same ratio while heating at 120^oC until the wax and oil content were digested and formed a clear solution. It was allowed to stand for about five minutes before distilled water was added, the content of the beaker was filtered and transferred to a 100 ml capacity volumetry flask and made up to the mark.

About 5ml of each of the samples of nail polish were pipette using a dropping pipette into a teflon beaker. Immediately(to prevent solidification), 15ml of 2:1 H_2SO_4/H_2O_2 was added. The reaction was highly exothermic and after the completion of the reaction, it was left to cool down before distilled water was added and filtered. The content was transferred to 100 ml capacity volumetry flask and made to the mark.

This procedure was repeated for each sample three times to ensure quality assurance of the work and 1000 ppm standard solutions were prepared from the salts of these chosen heavy metals and were serially diluted (Bruce and Whiteshide, 1984) as working solution for calibrating the AAS used for the analysis. All salts were analytical grade of British Drug House (BDH) chemicals. The samples were analyzed at Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, with AAS(Buck Scientific 200A model, East Norwalk, CT 06855-1023, USA) using air- acetylene flame at the most sensitive wavelength. The actual concentrations of the metals were determined using the dilution factor.

Statistical Analysis

Statistical package for Social Sciences (SPSS, version 17.0, Chicago IL, USA) was used to determine the descriptive and inferential statistics.

Results and Discussion

Tables 1 and 2 showed the mean concentrations of heavy metals in nail polishes and lipsticks determined in this study. The range of concentrations in nail polishes were: Pb (BDL − 42.14) µg/ml, Ni (1.88 – 4.22) µg/ml, Cd (5.90 –8.12) µg/ml, Mn (0.76 – 6.32)µg/ml, Cr (1.48 – 3.02) µg/ml and As (0.16 – 0.42)µg/ml while the concentrations in lipstick samples ranged as follows: Pb (15.6 – 124.2) µg/g; Ni (12.2 – 20.4) µg/g; Cd (18.6 – 38.2)µg/g; Mn (10.4 – 23.4) µg/g; Cr (6.6 – 28.4) µg/g and As (0.8 – 3.0) µg/g. The nail polishes were the same brand with different colours, lead is more accumulated in all the nail polish samples except for the white color (sample 2) whose concentration was below detection limit implying very low lead content. The reason could be due to the fact that lead and lead compounds are colorants (HSDB, 2009) which might not be applied in this sample. Lead and cadmium are two potentially harmful metals that have aroused considerable interest from the results obtained. 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). Amartey et. al., (2011) found Pb to be above 1.0ppm recommended for cosmetics by Ghana Standards Board. Khalid et. al., (2013) found Pb to be 48.0ppm in brand 4 of their lip sticks study, the average mean value in this study was 30.43 µg/g; Sainio et. al., (2001) found Pb to be less than 20ppm in 88 samples of eye shadow. It has been reported that the use of lead based cosmetics and herbal remedies might have led to high level of Pb in breast milk up to 130 μg Pb/l in nomadic Fulani women in Northern Nigeria (Nnoromi *et al*., 2005). Obi et. al., (2006) revealed that 100% of Nigerian herbal remedies contained elevated amount of lead. Nail polishes and Lipsticks are organic base, elevated Pb may be from the starting materials and colorants. One way T- test was conducted at 95% confidence interval to know the effects of the color on the metal concentrations (Table 1 and 2), it was found that all the metal concentrations were dependent on the colors. The colorants were main source of metals. The USFDA (US Food and Drug Administration) limit for lead as color additive in cosmetics is 20 ppm. So in all colors both in nail polishes and lipsticks, the lead concentration were above the FDA limit. To buttress this point correlation matrix was carried out on the samples. In nail polishes, sample 2,whose Pb concentration was below detection limit was negatively correlated with other samples. In the lipstick samples, samples were categorized into two based on the Pb content. Samples 1,2 and 3 whose range of Pb concentration was (15.6- 20) µg/g were highly positively correlated with r^2 value of 0.79, 0.87 and 1.00 while samples 4 to 10 were also better positively correlated with r^2 values $\geq$ 0.91.

It has been reported that Cd are present in lipstick and face powder as colorants and with about 0.5% absorption capacity through the skin but binds to epidermal keratin (Chauhan et. al., 2010). The proposed allowable limit of impurity of Cd in cosmetics by Health Canada (2009) due to absence of

international limit of metal impurities in cosmetics was 3ppm. This call for concern because of its high concentration of 6.66µg/ml in the nail polishes and 28.4 µg/g in lipstick. The requirement for Pb in cosmetic products is 1.0 ppm according to the Ghana Standards Board, however there is no available permissible limit on Cd for such products(Amartey et.al.,2011).

The lead and cadmium concentrations were higher in all the tested colors, when the total mean value of all colors were calculated, followed by the nickel (both in nail polishes and lipsticks). Figures 1 and 2 showed the percentage composition of the heavy metals in the samples, similar result was obtained by Khalid et. al., (2013). Cadmium is a toxic metal, it has been found to be connected with diabetes and high blood pressure(Godt et. al., 2006).
The average concentrations of Cr in nail polishes and lipsticks were (1.64±0.0005)µg/mL and (17.1± 0.004) µg/g respectively. Chromium (VI) compounds are toxins and known human carcinogens, whereas Chromium (III) is an essential nutrient. Breathing high levels can cause irritation to the lining of the nose, asthma and shortness of breath or wheezing. Skin contact can cause skin ulcers. Allergic reactions consisting of severe redness and swelling of the skin have been noted. Long term exposure can cause damage to liver, kidney circulatory and nerve tissues, as well as skin irritation (Eastern Research Group, 2001). Small amounts of Nickel are needed by the human body to produce red blood cells, however, in excessive amounts, can become mildly toxic. Short-term overexposure it to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation. The EPA does not currently regulate nickel levels in drinking water(Eastern Research Group, 2001). Manganese is an essential component of over 36 enzymes that are used for the carbohydrate, protein and fat metabolism. When manganese uptake takes place through the skin it can cause tremors and coordination failures. Laboratory test animals have shown that severe manganese poisonings could cause tumor development with animals(Agency for Toxic Substances and Diseases Registry, 2008).

As, Mn Cr were within the range of concentration 3ppm proposed for metals in cosmetics by Health Canada (2009). As the had the lowest concentration in this study, metals at low concentration in the body due to its bioaccumulation and being non degradable are dangerous to human health. The cumulative effects over time, since these cosmetics are use daily could be dangerous. These brand were not labeled to know the chemical composition, it was difficult to confirm the percentage composition of these metal in them.

Conclusion

This study showed that heavy metals in the nail polishes and lipsticks were above the proposed limit of metal in cosmetics Health Canada (2009) and Ghana Standards Board of 1.00 ppm of Pb in cosmetics. However, the absence of allowable limit of metals in cosmetics by international bodies limits our judgment. The study also revealed that lead and lead compounds used as colorants play significant role in the elevation of the metals in the cosmetics as other metals serves as impurities in them. The herbal materials/ products used in preparation of these cosmetics played significant role in elevating the metals in the final products.
The daily use of these cosmetics should aroused the regulatory bodies in Nigeria to regulate and enforce the limit of these metal in the cosmetics as the prevalence of cancer is on the increase in women, the main user of these products.

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Table 1: Concentration (µg/ml) of Heavy metals in Nail polish Samples

		Metals ($\bar{X}$ ± SD)					
Sample No	**Colors**	**Cd**	**Cr**	**Mn**	**Pb**	**Ni**	**As**
1	Orange	8.12 ± 0.004	3.02±0.0003	6.32 ±0.0014	42.14 ±0.0008	3.26±0.0004	0.52 ±0.0002
2	White	6.52 ±0.0019	2.36±0.0004	2.44 ±0.0008	BDL	3.06±0.0005	0.28 ±0.0006
3	Lilac	6.04 ±0.0010	2.02±0.0002	2.30 ±0.0006	19.54 ±0.0005	2.80±0.0006	0.16 ±0.0003
4	Blue	6.62 ±0.0004	2.74±0.0017	2.76 ±0.0005	24.78±0.0004	4.22±0.0004	0.30±0.0008
5	Baby pink	6.98±0.0006	2.64±0.0003	0.76 ±0.0005	28.58 ±0.0003	3.66±0.0009	0.42 ±0.0001
6	Red	5.90 ±0.0006	1.48±0.0004	1.62 ±0.0008	33.02 ±0.0003	4.00±0.0006	0.20 ±0.0006
7	Black	6.76 ±0.0005	1.88±0.0006	2.16 ±0.0005	32.18 ±0.0003	2.66±0.0007	0.18 ±0.0002
8	Fusia pink	6.92 ±0.0003	2.06±0.0004	2.20 ±0.0009	31.78 ±0.0007	2.58±0.0004	0.34 ±0.0010
9	Brown	6.36 ±0.0010	2.24±0.0003	0.96 ±0.0004	32.56 ±0.0008	1.88±0.0005	0.22 ±0.0005
10	Fusia pink with filler	6.36 ±0.0010	2.00±0.0005	0.98 ±0.0006	29.28 ±0.0003	2.22±0.0004	0.20 ±0.0008
Average Mean Concentration	-	6.66 ±0.0008	1.64±0.0005	2.25 ±0.0006	30.43 ±0.0005	3.03±0.0005	0.28 ±0.0004
Test for difference in means	One way T-Test	33.885	15.533	4.473	14.700	12.648	7.661
	Mean Difference	6.65800	2.24400	2.25000	30.42889	3.03400	0.28200
	P- value (0.05)	0.000	0.000	0.002	0.000	0.000	0.000

BDL - Below Detection Limit

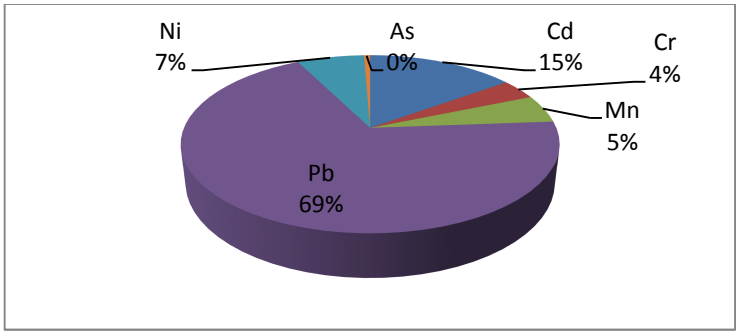

Figure 1: A pie chart showing the percentage composition of heavy metals in nail polishes

Table 2: Concentration (µg/g) of Heavy metals in Lipstick Samples

		Metals ($\bar{X}$ ± SD)					
Sample No	Colors	Cd	Cr	Mn	Pb	Ni	As
1	Red	26.0±0.0012	11.8±0.0004	8.6±0.0006	15.6±0.0010	20.2±0.0007	1.2 ±0.0001
2	Orange	30.6±0.0010	14.6±0.0008	23.4±0.0007	17.2±0.0010	17.8±0.0005	2.0 ±0.0002
3	Fusia pink	38.2±0.0004	14.4±0.0003	20.2±0.0004	20.0±0.0005	18.4±0.0006	3.0 ±0.0004
4	Deep brown	34.6±0.0007	6.6 ±0.0001	19.6±0.0001	111.2±0.0005	13.2±0.0010	2.6±0.0010
5	Ash	30.2±0.0008	12.2±0.0006	19.8±0.0001	66.0 ±0.0010	20.4±0.0010	2.2 ±0.0011
6	Light brown	34.4±0.0011	18.2±0.0005	10.4±0.0003	71.6 ±0.0007	16.2±0.0009	1.6 ±0.0006
7	Wine	18.6±0.0006	15.2±0.0004	16.6±0.0005	82.4 ±0.0002	12.2±0.0004	0.8 ±0.0007
8	Black	21.4±0.0010	12.2±0.0004	20.6±0.0005	65.2 ±0.0002	18.0±0.0004	0.8 ±0.0002
9	Baby pink	27.8±0.0012	28.4±0.0007	13.0±0.0002	64.8 ±0.0006	22.0±0.0006	1.6 ±0.0008
10	Blue	22.2±0.0010	24.0±0.0002	18.8±0.0005	124.2±0.0006	18.4±0.0005	1.2 ±0.0005
Mean concentration	-	28.4±0.0009	15.76±0.0004	17.1±0.0004	63.82±0.0006	17.68±0.0007	1.70±0.0006
Test for difference in means	T- statistic	14.042	7.858	11.137	5.368	18.102	7.227
	Mean Difference	28.400	15.7600	17.1000	63.8200	17.6800	1.7000
	P- Value (0.05)	0.000	0.000	0.000	0.000	0.000	0.000

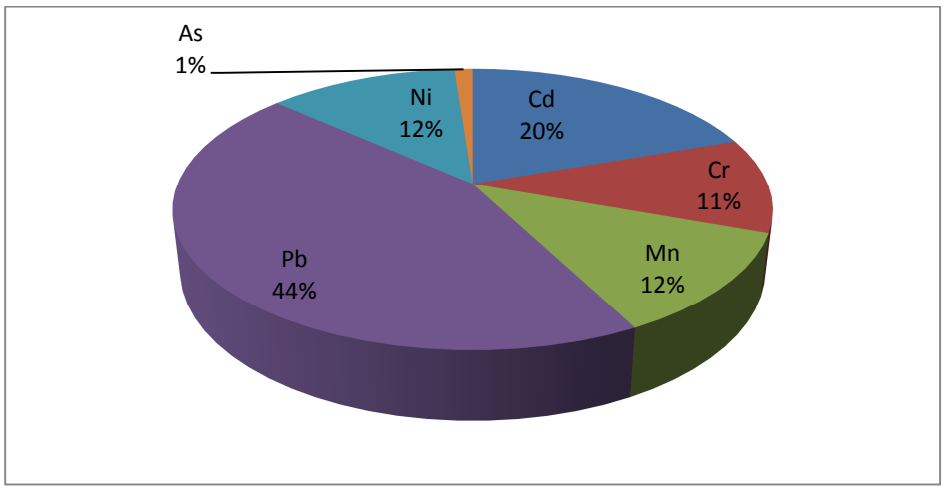

Figure 2: A pie chart showing the percentage composition of heavy metals in lipsticks

Table 3: Correlation Matrix of the Nail Polish samples

	Sample 1	*Sample 2*	*Sample 3*	*Sample 4*	*Sample 5*	*Sample 6*	*Sample 7*	*Sample 8*	*Sample 9*	*Sample 10*
sample1	1									
sample2	-0.37512	1								
sample3	0.989373	-0.26067	1							
sample4	0.991076	-0.30089	0.998086	1						
sample5	0.985145	-0.31837	0.994746	0.996762	1					
sample6	0.992304	-0.37022	0.991879	0.996635	0.996365	1				
sample7	0.995699	-0.34782	0.995657	0.997051	0.996556	0.99801	1			
sample8	0.995434	-0.34487	0.995788	0.99676	0.996612	0.997498	0.99996	1		
sample9	0.992555	-0.36079	0.992867	0.994534	0.997262	0.996662	0.998957	0.999145	1	
sample10	0.991592	-0.34057	0.995081	0.996177	0.998515	0.997034	0.999166	0.999339	0.999672	1

T**able 4: Correlation matrix of lipstick samples**

	Sample 1	*sample 2*	*sample 3*	*sample 4*	*sample 5*	*sample 6*	*sample 7*	*sample 8*	*Sample 9*	*Sample 10*
Sample1	1									
Sample2	0.794303	1								
Sample3	0.876521	0.955978	1							
Sample4	0.303137	0.237412	0.307384	1						
Sample5	0.463208	0.393034	0.445973	0.979876	1					
Sample6	0.479856	0.336537	0.434527	0.964407	0.973563	1				
Sample7	0.244602	0.17939	0.219595	0.982423	0.962961	0.953487	1			
Sample8	0.351149	0.310487	0.332175	0.97897	0.987673	0.950446	0.984699	1		
Sample9	0.465542	0.298564	0.360253	0.910476	0.934729	0.969643	0.942934	0.933535	1	
Sample10	0.220854	0.122776	0.167694	0.971959	0.947719	0.946394	0.99734	0.973913	0.946007	1

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