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Investigation of Mercury Content in Cosmetic Products by Using Direct Mercury Analyzer

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ABSTRACT

Mercury is a toxic metal and can cause serious health effects including kidney damage, anxiety depression and peripheral neuropathy. Beside the traditional sources of mercury such as industry mining, new sources of mercury exposure came to existence through cosmetics such as soaps, skin and whitening creams. In this study, eight samples of different brands of skin whitening creams were analyzed by Direct Mercury Analyzer (DMA) for the determination of mercury content. Quantification of mercury levels in these products was achieved by using external standard calibration curve method. The mercury levels in the studied skin whitening creams ranged from 0.00 ppm to maximum of 3.373ppm. The results showed that skin whitening creams have mercury level at detectable levels and is enough to cause adverse health effects. The study concluded that the Direct Mercury Analyzer (DMA) instrument proved to be an excellent tool for screening mercury in skin creams. This technique offers the advantages of simplicity, rapidity, low detection limit, accuracy and precision and no sample preparation.

Keywords: Direct Mercury Analyzer (DMA), Mercury, Toxicity.

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INTRODUCTION

Whitening products are commercial preparations containing chemicals that produce a whitening effects on the human skin. The mechanism of their action proceeds through interrupting the synthesis of melanin- which acts to reduce the effect of sun on human skin. The function of the added chemicals to whitening creams is to remove the dead skin cells. Mercury-in particular- can block the production of melanin and reduces the amount of the produced melanin[1]. Mercury usage in cosmetics takes two chemical forms: inorganic and organic. Inorganic mercury which occurs as salts of mono and divalent mercury and ammoniated mercury is an example. The second form which organic mercury compounds is basically used as cosmetic preservatives e.g. phenyl mercuric salts[2]. There is a considerable body of literature that deals with mercury as well as other heavy metals toxic effect. Mercury has respiratory, cardiovascular, gastrointestinal, hepatic, renal impairment and reproductive effects. Moreover, mercury was associated with elevated white blood cells, changes into auto-immune response, drop in vision and genotoxic effects[2-4]. Whitening creams have a lot of active ingredients and range from hydroquinone, mercury or even corticosteroids. All these ingredients have been reported to cause serious side effects. Mercury topical preparations are absorbed through the skin into the blood stream and accumulates in the liver mainly, the absorbed amount varies according to the chemical form of mercury and the other constituents of the preparation. Tonga[5] and Florea[6] reported that experimental on animals had shown that mercury can affect the central nervous system through crossing the placenta and reach the fetal brain. Due to toxicity of mercury, the United States Food and Drugs Administration[7] (US FDA) in 1992 set a value of less than1ppm for mercury in cosmetics. Many studies had been conducted to identify and quantify mercury in cosmetic preparations and extremely high levels of mercury[1] were detected [1,8-11].

MATERIALS AND METHOD

Mercury stock standard solution concentration of 1000µg/Kg. purchased from Fisher Scientific, UK. HCl(37%) Scharlau, Spain, Highly purified water (interference free).

Samples

A total of 8 samples of whitening creams were purchased from a community pharmacy and beauty shops in Khartoum, Sudan. Sample details are given below in Table1.

Table 1: The different brands of skin whitening creams used in the study

Cream	Manuf.date	Expiry date
Beauty gel	2014	2017
Avalon	2014	2016
Melano free	2014	2016
Amaluco	2014	2017
Lucocid	2014	2017
Fair and lovely	2014	2016
Garnier skin natural	2014	2015
Olay	2014	2017

Equipment's

The DMA-80 automatic mercury analyzer (Milestone, Inc.). Compressor for oxygen high purity supplier (Milestone, Inc.). Analytical balance, max capacity 220g,(Sartorius 00578, Deutschland).

Preparation of Calibration Standards

A series of dilution covering a wide range of mercury concentration was made from the stock solution and conc HCl (37%) according to the following protocol shown in Table 2.

Table2: Preparation of the standard mercury solutions

No.	conc of the stock	Volume taken ml	Volume made up	Concentration (ppm)
1	1000µg/Kg	10	100	100
2	100ppm	1		1
3		2		2
4		5		5
5		7		7
6		10		10

Principle of Operation of Direct Mercury analyzer DMA-80

Direct mercury analyser DMA-80is a dedicated technique used for quantification of mercury in different types of samples. Many types of this instrument are available commercially and the type used in this study is the Direct Mercury analyser-DMA-80 (See Figure 1). In Principle, the sample (solid, gas or liquid) is introduced to the instrument and a series of events takes place in the analyser. First the sample is dried and thermally decomposed in a furnace in a presence of oxygen. After this step, the sample is carried over where it is further combusted and decomposed in a catalyst section where halogen, nitrogen, sulphur oxides are eliminated. Mercury vapour is selectively trapped by and an amalgamator and then directed to the atomic absorption set at mercury line (253.7 nm). Quantification of mercury is achieved by the use of external standard calibration curve method.

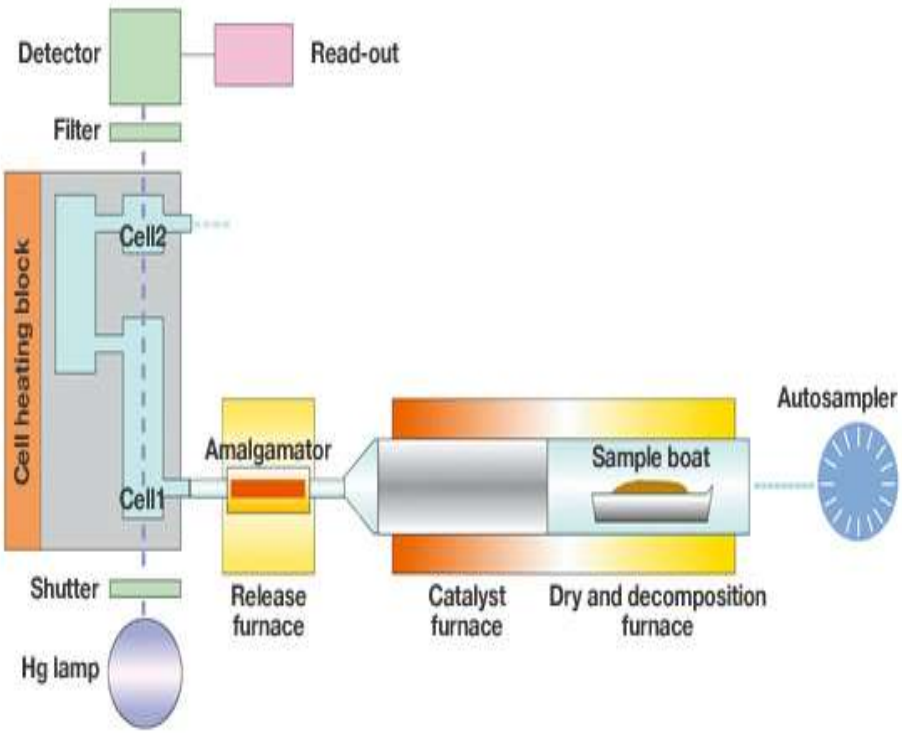

Figure 1: Direct Mercury Analyzer DMA-80 Instrument used in the study

Exactly 0.10g of each brand was introduced to atomic absorption spectrometer. Samples were placed in the sample boat as shown in Figure 1 and were allowed to dry and decompose in a furnace in the presence of oxygen to liberate mercury. A stream of oxygen carries the products to the catalytic section of the furnace and then to the amalgamator where mercury is trapped and releases its vapour which is consequently focused to the atomic absorption spectrophotometer that is set at the mercury line (253.7 nm).

RESULTS AND DISCUSSION

Initially calibration curve of standard mercury at different concentrations was constructed using the following concentration. The software of the instrument produced the following a calibration curve shown in Figure 2.

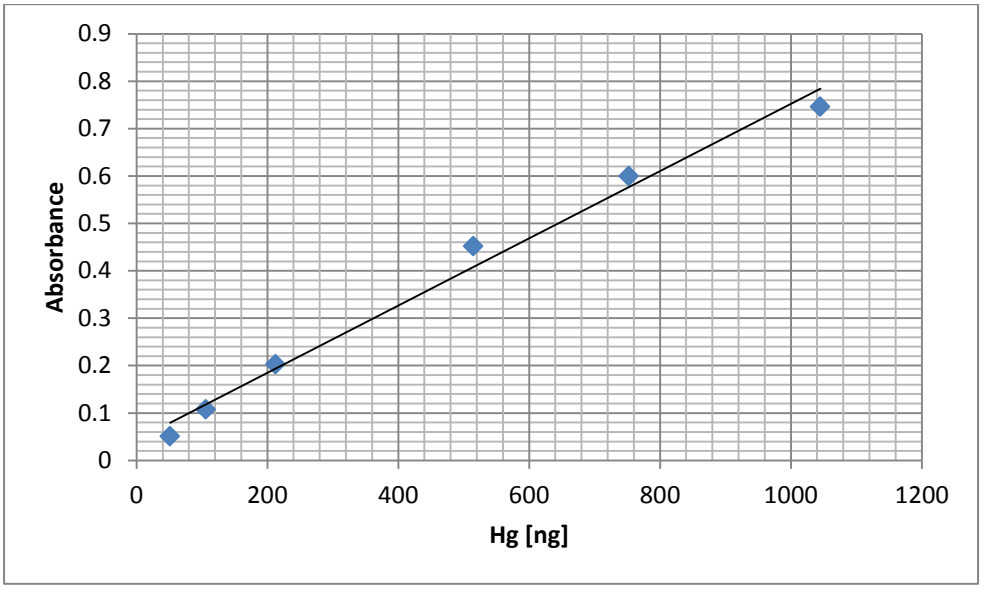

Figure 2: The calibration curve of the standard mercury solutions

Based on the calibration curve, the results of the mercury measurements in the whitening creams are shown in table3.

Table 3: The concentration of Hg in the whitening creams samples

Sample	Hg concentration(ppm)
Beauty gel	1.715
Avalon	2.308
Melano free	3.373
Amaluco	3.198
Lucocid	1.883
Fair and lovely	0.035
Garnier skin natural	0.521
Olay	Not detected

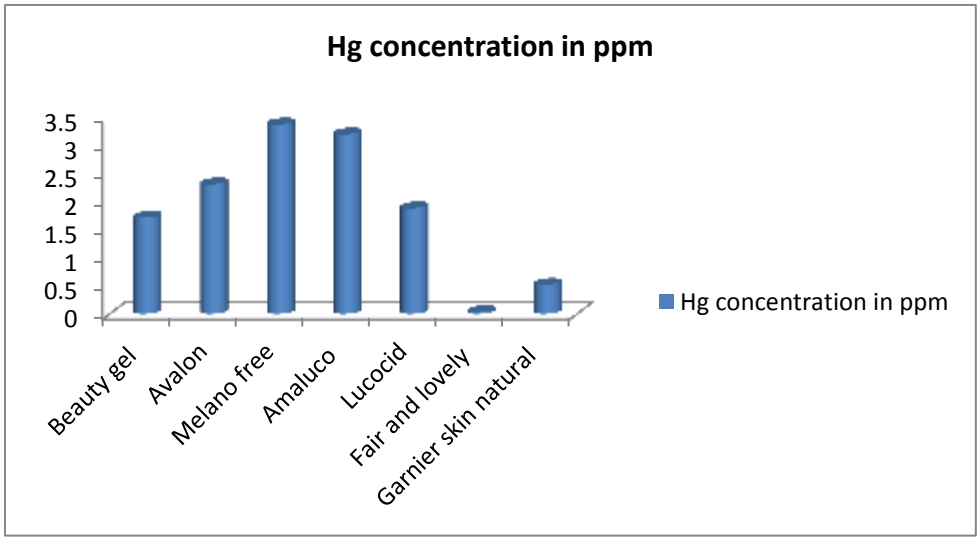

Figure 3 the concentration of mercury in samples

Out of eight samples collected only one sample does not contain mercury, and only two samples below the limit stated by The United States Food and Drugs Administration (US FDA) which is less than 1 ppm. The highest concentration of mercury 3.373ppm was found in Melano free followed by Amaluco cream (3.198 ppm). The least mercury concentration was found to be 0.035 ppm in Fair and Lovely cream. It is noteworthy that in all the investigated skin whitening creams no labels were there to indicate the presence of mercury content. In mercury analysis, the most widely used methods for quantification of mercury employ atomic spectrometry whether based on absorption or emission phenomena. Examples include Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) which offers the advantages of precision, accuracy and provides multi-element analysis capability but it is prone to interference. The use of mass spectrometry as a detector (ICP-MS) for this technique can improve the quality of the results and eliminates the interference to a large extent. Another potential technique for mercury determination is X-ray fluorescence. The analysis by this technique is simple, fast and cost-effective. Atomic absorption spectrophotometer coupled to graphite furnace is also another versatile technique for mercury determination. Speciation analysis i.e. the determination of the different chemical form and the oxidation state of the element of interest, is needed[12] in studies dealing with toxic metals in cosmetics. An important aspect of metallic analysis by spectroscopic technique is the fact that the results represent the total element concentration and do not reveal the valency state of a particular metal. The current studies focus on the total mercury concentration but the determination of the exact metallic state is critically important when toxicity is the issue. Such speciation analysis can provide information to exactly assess the fate and the risk of the element(s) under consideration. For instance, Cr (IV) compounds are carcenogenic while Cr (III) are important as they have some biological activity and for this reason the total metal concentration might not be helpful in this respect. To conclude, it could be said that when chemical activity, toxicity, bioavailability and mobility are the issues, total metal concentration determination may not provide complete data for the assessment of the risks and the hazards associated with the metal(s) in question as these parameters are species characteristics. Scientific advances have coupled ion chromatography and ICP-MS as a detector. This interface of the three instruments does suit speciation analysis and provides a detection limit in the range of 1-10 ppt (ng/L) but it's disadvantage is the need for careful and tedious optimization of the chromatographic conditions. Another point to highlight in trace metal analysis is the importance of the detection limit of a particular instrument that is used for such analysis. For instance, mercury and other toxic metals might exist in trace amounts beyond the detection limit and therefore quantification is not attainable. However, the use of direct

mercury analyser offers the advantage of extremely low detection limit (0.001ppb). In addition to this, it also offers high reproducibility, short analysis time (5 minutes per sample), no sample preparation, ability to analyse solid liquid and gas samples and ease of use. Moreover, calibration of the instrument can be achieved by using mercury as a solid or a liquid reference material and this due to the fact that the instrument is matrix-independent or in other words there is no need for matrix matching of the sample and the standard. This is especially true and of high importance when considering the fact that the cosmetic products have many ingredients i.e. complex matrix and difficult to match. However, different studies for the assessment of mercury in cosmetics revealed very high mercury concentration in cosmetics[13]. Such fact necessitates the importance of curbing and controlling the use of mercury products in cosmetic preparation.

CONCLUSION

The results indicate that mercury content in whitening creams was high in five analyzed samples than the threshold value of 1ppm set by the U. S. Food and Drugs Administration (FDA).

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