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Research Article

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Determination of lead Element in Hair Dye Samples Available in Libyan Markets Using Atomic Absorption Spectroscopy

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Abstract

Hair dyes are essential to cosmetic products; however, they may contain harmful chemicals that pose health risks when used repeatedly. This study analyzed six commercial hair dye samples available in the Libyan markets, representing multiple colors (black, blonde and brown) to ensure a comprehensive assessment. Advanced analytical techniques, specifically Atomic Absorption Spectroscopy (AAS), were employed to determine the lead concentration in the samples. Random samples were selected from the markets for analysis, and the results revealed that most samples had undetectable levels of lead (<0.1 µg/L) for samples 1 to 3. However, sample 4 exhibited a significant lead concentration, with an average value of 12.92 µg/L, ranging from 10.2 µg/L to 14.56 µg/L. Samples 5 and 6 were also free from detectable lead. This study emphasizes the importance of continuous monitoring of cosmetic products, particularly regarding heavy metals that could pose public health risks. The findings suggest that some products contain elevated lead levels, highlighting the need for preventive measures to ensure consumer safety. Additionally, the study calls for increased consumer awareness of the risks of lead exposure and the importance of selecting safe products.

Keywords: Hair Dyes, Lead, Atomic Absorption Spectroscopy (AAS), Heavy Metals.

INTRODUCTION

Heavy metals, especially lead, are considered as a major environmental and health hazards. Lead exposure can occur through various sources; including contaminated air, water, soil, food, and consumer products. In particular, cosmetic products such as hair dyes are increasingly scrutinized due to the potential presence of harmful substances like lead, which can be absorbed through the skin and cause serious health effects. Chronic exposure to lead is known to adversely affect the nervous system, kidneys, and reproductive system, particularly in vulnerable populations such as children, pregnant women, and those with pre-existing health conditions (Bellinger, 2017; World Health Organization, 2019).

Lead is classified as a neurotoxin and its presence in personal care products especially those

applied directly to the skin, is a significant public health concern. Although various studies indicate the presence of heavy metals, including lead, in cosmetic products globally (Hussein et al., 2020; Ugochukwu et al., 2021), the situation in developing countries, such as Libya, remains underexplored. Given that the cosmetics market in Libya has seen significant growth over the past few decades, it is crucial to assess the safety of products available to consumers (Rasool et al., 2016). The Atomic Absorption Spectroscopy (AAS) is one of the most reliable techniques for detecting and quantifying trace elements such as lead in various samples, including cosmetics. AAS has become the standard method for heavy metal analysis due to its sensitivity, precision, and ability to detect low concentrations (Cohen et al., 2022; Chojnacka et al., 2005).

This study aims to determine the concentration of lead in some imported hair dye samples available in Libyan markets using AAS. The research will contribute to filling the gap in knowledge regarding the safety of cosmetic products in Libya and will help raise awareness about the potential risks posed by lead contamination in such products.

MATERIALS AND METHODS

T **Materials**

Six samples of hair dye, concentrated nitric acid HNO_3 (69.5% for Carlo Erba analysis) were used to digest the samples, and distilled water.

Equipment Apparatus

Atomic Absorption Spectrometer (AAS), Filtration equipment (filter paper, funnel, etc.), graphite furnace type Varian-USA

Sample Collection

Six dye samples were collected from different stores in the Libyan market. The selected dye types were among the most common types used by consumers in the markets.

Preparation of Sample

1. To prepare the sample for lead analysis, approximately 1-2 g of the hair dye sample is accurately weighed into a clean, heat-resistant crucible. The sample is then ignited in a muffle furnace at 550°C for 2-3 hours to ensure complete combustion, converting all elements into their oxide forms and removing any organic matter. After cooling, the ash is transferred into a beaker, and a few milliliters of concentrated nitric acid (HNO_3) are added to dissolve the ash and release the lead content into the solution. The solution is gently heated in a fume hood to ensure complete digestion of the ash, as vapors from the nitric acid are released during this process (Cohen, J., Smith, T., & Davis, R. 2022)

2. Once digestion is complete and the solution becomes clear, it is filtered through filter paper to remove any insoluble particles, such as remaining ash or unreacted materials. The filtered solution is then transferred into a volumetric flask and diluted with distilled water to a final volume of 50 mL. This dilution ensures that the lead concentration falls within the measurable range for Atomic Absorption Spectroscopy (AAS).

3. For the blank solution, a clean crucible is ignited in the muffle furnace at 550°C for 2-3 hours to remove any organic matter. After cooling, a small volume of concentrated nitric acid is added to the crucible and gently heated to digest the acid. After digestion, the acid is directly

transferred into a clean beaker and then diluted with distilled water to a 50 mL volume. This blank solution is essential to account for any potential interference or contamination from the reagents during the lead determination process (ASTM International, 2022).

RESULTS

Calibration curve of lead standard

The standard linear calibration curve was obtained from the analysis of standard solutions (Table 1). It showed a relationship between the absorbance and concentrations of the standard solutions (Figure 1).

Table (1). Relationship between the concentration and the absorption of lead.

Concentration	Absorbance
0	0
0.01	0.01
0.02	0.015
0.04	0.029

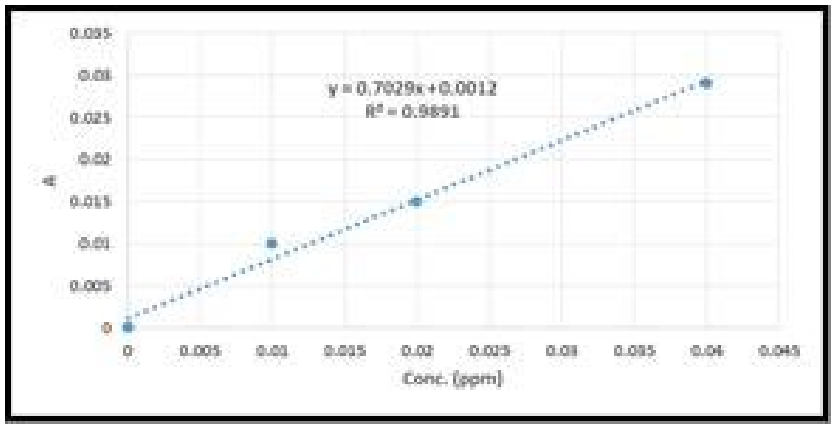

Figure (1). The calibration curve of lead.

Table (1) shows the relationship between each concentration of lead and its absorption value. This relationship can also be observed in Figure (1) on a linear scale. As a result, the concentration of metal content (mg/Kg) can be calculated (Bnhmad, Mona et al., 2024).

Table (2). Concentration of lead in hair dye.

Samples	R1	R2	R3	Average(µg/L)
1	<0.1	<0.1	<0.1	<0.1
2	<0.1	<0.1	<0.1	<0.1
3	<0.1	<0.1	<0.1	<0.1
4	14.56	10.2	14	12.92
5	<0.1	<0.1	<0.1	<0.1
6	<0.1	<0.1	<0.1	<0.1

The analysis of hair dye samples available revealed that the majority of the samples contained lead concentrations below the detection limit (<0.1 µg/L), except sample 4, which exhibited significantly higher levels of lead (12.92 µg/L on average).

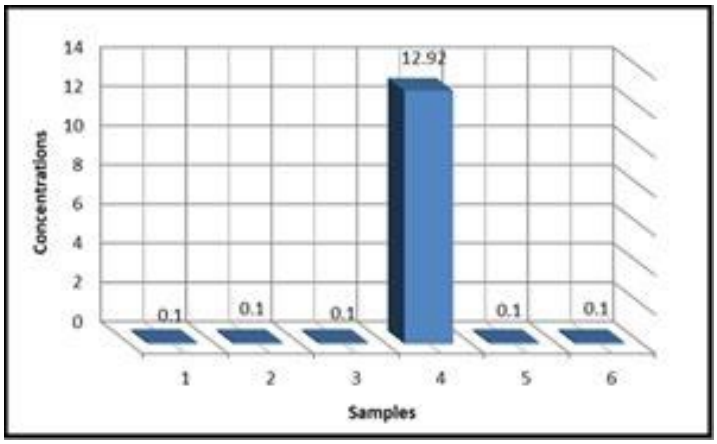

Figure (2). Concentration of lead in hair dye

DISCUSSION

The measurements presented in table (2) show that the concentrations of lead (Pb) in hair dye samples were mostly below the detection limit (<0.1 µg/L) for most of the samples (samples 1, 2, 3, 5, and 6). However, for sample 4, the concentration is significantly higher, with values of (12.92 µg/L).

The significant increase in lead levels in sample 4 could be attributed to several factors:
Hair dyes may contain ingredients sourced from various raw materials, some of which may be contaminated with lead. Lead can enter the formulation of dyes if used in certain steps of processing or if raw materials are contaminated. Studies have shown that various industrial processes, particularly in countries with weaker regulatory frameworks, can unintentionally introduce heavy metals like lead into consumer products (Vargas et al., 2014).

Some hair dyes, especially older formulations, may contain lead acetate or lead-containing compounds to enhance the coloring effect. Lead acetate, in particular, has been used in hair dyes as a colorant and in some darkening products. While the use of lead acetate has been restricted in many countries, it might still be found in certain products, especially those imported from regions with less stringent regulations (U.S. Food and Drug Administration, 2020). This might explain the elevated levels in sample 4 if it contains lead-based pigments that were not properly regulated or disclosed on the product label.

Lead contamination can also occur due to environmental factors; for example, the exposure of hair dye products to lead-contaminated surfaces or containers during transportation or storage could result in trace amounts of lead being incorporated into the product. Such contamination could be more significant if the products were stored in older facilities or transported using materials that were previously in contact with lead-based substances (Kaur et al., 2015).

It is possible that sample 4 was imported from a different batch or manufacturer, which could have influenced the level of lead contamination. Variations in the source of raw materials, quality control processes, and manufacturing facilities could explain why sample 4 has elevated lead levels while other samples remain below detection limits.

Lead is a regulated substance in consumer products like hair dye; for example, the European Union (EU) restricts the use of lead in cosmetics to a maximum of 0.5 µg/g in finished products (European Commission, 2019). If sample 4 violates these standards, this could suggest that it either came from an unregulated source or failed to meet the safety guidelines enforced by authorities.

CONCLUSION

In this study, the findings suggest that while most products are free from detectable lead contamination, certain hair dye products may contain elevated lead levels due to various factors such as contamination during manufacturing, the use of lead-based pigments, environmental contamination, or differences in manufacturing processes.

Although the presence of lead was minimal in most samples, even small amounts of lead can pose health risks, especially with prolonged or repeated exposure.

To improve consumer safety, it is important to strengthen regulations on heavy metals in cosmetics, particularly lead, by aligning with international standards. Public awareness campaigns should educate consumers on the risks of lead exposure and encourage the selection of safe products. Additionally, regular testing of cosmetics, especially imports, is necessary to ensure safety.

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REFERENCES

ASTM International. (2022). ASTM D4975-22: Standard test method for lead in paint by atomic absorption spectroscopy. ASTM International.

Bellinger, D. C. (2017). Lead neurotoxicity and the developing brain: Implications for the prevention of neurodevelopmental disorders. *Environmental Health Perspectives*, 125(4), 451-457.

Bnhmad, M. H. A., Alterhoni, E., benhamad, O., & Amimn, A. M. (2024). Estimate of Sodium Benzoate Preservative in Some Soft Drinks in Local Markets in Libya Using a UV-Spectrometer. *Tarbawe Journal*. 24, 189-193. http://tarbawej.elmergib.edu.ly.

Chojnacka, K., Górecka, H., Chojnacki A., and Górecki, H. (2005) Inter-element interactions in human hair. *Environ Toxicol Pharmacol*, vol. 20, no. 2, pp. 368–374.

Cohen, J., Smith, T., & Davis, R. (2022). Application of Atomic Absorption Spectrometry in the analysis of heavy metals in personal care products. *Journal of Environmental Analytical Chemistry*, 45(2), 134-145.

European Commission. (2019). Regulation (EC) No 1223/2009 on cosmetic products. *Official Journal of the European Union*.

Hussein, S. A., Al-Kahtani, S. A., & Rahman, M. A. (2020). Heavy metals in cosmetics: Sources, exposure routes, and health effects. *Environmental Toxicology and Pharmacology*, 74, 103332.

Kaur, M., & Prakash, S. (2015). Environmental contamination by heavy metals in cosmetic products. *Environmental Toxicology and Pharmacology*, 39(3), 1122-1129. [DOI: 10.1016/j.etap.2015.02.006]

Rasool, S. R., Al-Dahhan, W., Al-Zuhairi, A. J., F., Hussein, Rodda, K. E., and Yousif E. (2016) Fire and Explosion Hazards expected in a Laboratory, *J Lab Chem Educ*, vol. 4, no. PNNL-SA- 118942.

U.S. Food and Drug Administration. (2020). Lead in Cosmetics. Retrieved from FDA.gov

Ugochukwu, M. I., Ogbu, C. A., & Ogbunugafor, H. A. (2021). Assessment of lead and other heavy metals in commercial hair dye products in Nigeria. *Environmental Monitoring and Assessment*, 193(4), 219.

Vargas, L., Rojas, J., Rodríguez, M., & Sáez, M. (2014). Heavy metal contamination in personal care products. *Journal of Environmental Science and Health*, Part A, 49(9), 987-993. DOI: 10.1080/10934529.2014.922045.

World Health Organization. (2019). Lead exposure and health. World Health Organization.