



Spectroscopic detection of health hazardous contaminants in lipstick using Laser Induced Breakdown Spectroscopy

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ABSTRACT

Laser Induced Breakdown Spectroscopy (LIBS) technique was applied to determine the concentrations of different toxic elements like lead, chromium, cadmium and zinc in four different lipstick brands sold at local markets in Saudi Arabia. These samples contain toxic elements like lead, cadmium and chromium which are carcinogen dermatitis, allergic and eczematous. Their extraction from human body takes over 40 years and accumulation in the body cause problems like disruption of nervous systems and kidney damage. They could trigger to systemic lupus erythematosus (SLE). In order to test the validity of our LIBS results, standard technique like (ICP-AES) was also applied. To the best of our knowledge, this is the first study where LIBS technique was applied for the measurement of toxic substances in lipsticks. The maximum concentration detected in four lipstick brands was much higher than the permissible safe limits for human use and could lead to serious health problems. It is worth mentioning that the lipstick is not a solid rather is in fluid state which is not trivial to analyze using LIBS technique. For this purpose, special treatment of the lipstick samples was necessary to analyze with our LIBS method.

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1. Introduction

It has been recently reported by the US Food and Drug Administration (FDA) and European Union's Restriction on Hazardous Substances (ROHS) directive that some cosmetic materials used by humans contain hazardous substances. Due to these reasons, there is a growing concern that some of the cosmetic products used by humans contain hazardous substances which are injurious to health [1,2]. Over time the use of cosmetic products worldwide is increasing at an alarming rate due to the everlasting pursuit for individual beautification and due to a sharp rise in product advertisements in the electronic media. Most of these cosmetic products are directly applied to the human skin. While the skin provides a great protective barrier, some of the ingredients in cosmetic products can penetrate the skin and reach vital internal organs via the systemic circulation. Cosmetic products which are applied to mucous membranes are even more hazardous, as in the case of lip products such as lipsticks. In addition to these risks, lipsticks also have the higher risk of direct oral ingestion, aggravating the negative effects of its chemicals [1–8]. Due to these reasons and concerns, the analysis and evaluation of their effects on the human

body are of paramount importance. The main concern for safety assessment of use of these products is the precise knowledge about the concentrations and native hazards of the ingredients present in these products. Some of the species absorbed from the skin are systemically transported to different organs around the body, where they can exhibit their toxicities for shorter and longer periods. Recently lipstick use has been reported to be a risk factor and an environmental trigger for developing Systemic Lupus Erythematosus (SLE) [2–6]. SLE is an autoimmune disease of unknown cause. Although there is a genetic predisposition, discordance between identical twins and among dispersed people of the same ethnic background suggests that environmental factors are also contributors to disease expression [2,3]. On the other hand Lead, which basically provides the pigment in colored lipsticks, is quite worrisome especially in the longer lasting red lipsticks. Although FDA does monitor lead levels in consumer products, levels above FDA limits can have detrimental effects, especially in sensitive populations like infants, children, pregnant women, and women of child bearing age. Lead is most toxic to fetuses, babies and children, whose nervous systems are still developing. Although lead is absorbed very slowly into the body, its rate of excretion is even slower. Thus, with constant exposure, lead accumulates gradually in the body. It is absorbed by the red blood cells and is circulated through the body where it becomes concentrated in soft tissues, especially the liver and kidneys. The nervous system is the most

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sensitive target for lead. It can cause permanent neurological and behavioral damage and can damage the cells that make up the blood–brain barrier which protects the brain from many harmful chemicals. Symptoms of lead poisoning include loss of appetite, weakness, anemia, vomiting, and convulsions, sometimes leading to permanent brain damage or even death. Newborns of mothers who had been exposed to lead appear to show signs of slowed mental growth, skeletal mal-development and encephalopathy depending on the time and period of exposure. Lead also has toxic renal, hematological, endocrine and reproductive effects, and is a risk factor for hypertension and its sequel. It is due to these harmful effects that the United States banned lead in paint since 1978 and phased lead out of gasoline completely in the mid-1990s.

Although chromium, in limited amounts, is an essential nutrient that helps the body use sugar, protein, and fat, however, breathing high levels of chromium can cause irritation to the nose, and cause runny nose, nosebleeds, and ulcers and perforations in the nasal septum. Ingesting large amounts of chromium can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death. Skin contact with certain chromium compounds can cause skin ulcers. For people who are extremely sensitive to chromium, allergic reactions consisting of severe redness and swelling of the skin have been noted [3]. But now we may have introduced another source of lead through the application of cosmetic products, a channel which needs tight scrutiny in view of safe permissible levels for consumer product use.

We have just pointed out few of the many concerns involved in lipstick use which pose a threat to ones health and wellbeing. Keeping in view the frequent everyday use of lipstick on a mass level, one can thus understand the importance of the chemicals involved. We have therefore assessed the individual chemical levels incorporated in the lipstick, which if above safe FDA limits can be injurious using a self developed laser induced breakdown spectrometer. The main aim of this study is the application of LIBS technique for rapid detection of toxic elements in cosmetic products like lipsticks which is a fluid (neither liquid nor solid) and not trivial to analyze by conventional methods where lengthy/or laborious sample preparation procedures and chemicals are required. It is worth mentioning that in the past LIBS technique for detection of these toxic elements in paint, soil, rock, iron slag, oil residue, oil spills and volcanic eruption samples [9–19]. However most of these samples were in solid phase and LIBS could be easily applied for analysis of such samples. To the best of our knowledge, there is no literature available where LIBS has been applied for detection of heavy metals in samples like lipstick which is neither liquid nor solid and this study is of its first kind where LIBS technique has been successfully applied.

2. Materials and methods

In our study, laser induced breakdown spectrometer (LIBS) was developed for the detection of hazardous contaminants in lipsticks such as lead, chromium and cadmium. LIBS technology provides a rapid elemental analysis of solids, liquids or slurries, and gases [9–24]. In LIBS technique, a strong laser pulse evaporates a small amount of material (typically a few micrograms) under test by creating a plasma plume. The light emitted by plasma is spectrally resolved to determine the chemical composition of the sample material. There are many processes that occur when a pulsed laser beam interacts with any solid material resulting in intense plasma, such as thermo ionic emission, sample heating, phase change, melting, atomization, excitation and ionization [9–24]. This study was focused on the analysis of lipstick, utilizing LIBS for the detection of toxic and trace elements present in four lipstick samples of different brands and price range (from cheap to expensive) sold at the

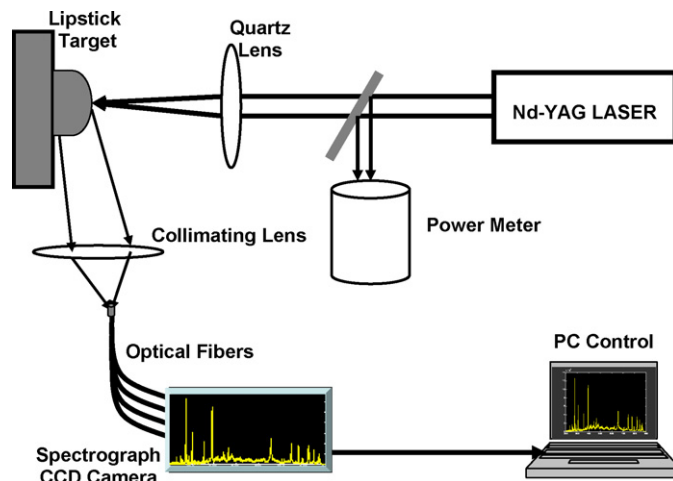


Fig. 1. Schematic diagram of the experimental setup applied for the analysis of lipstick samples.

local market. The four lipstick samples were procured from cosmetic shops in the Kingdom of Saudi Arabia. Sample #1 and sample #2 were low cost unbranded lipsticks manufactured in China and India while sample #3 and sample #4 were branded as LIP Care and Rouge Allune Luminous Satin. As we know that the lipstick is not in the form of solid rather is in a fluid state which is not trivial to analyze by LIBS technique. Special treatment of the samples was necessary to study the LIBS spectrum. To the best of our knowledge, this is the first study of its kind where LIBS technique has been applied for the measurement of toxic substances in lipstick. The concentration of each trace metal determined with LIBS technique was also verified by a standard method such as ICP. The results achieved with LIBS techniques agrees well with ICP method.

2.1. Setup and procedure

The schematic diagram of our LIBS experimental setup for detection of hazardous elements present in lipstick samples is depicted in Fig. 1. The LIBS setup applied in this work has been described in detail in our previous publications [9–14] and briefly described here. The light from the plasma spark is collected by a collimating lens using UV graded fused silica 1 m, multimode sampling fiber with subminiature version A (SMA) connector is transferred to LIB2000 + Spectrometer (Ocean Optics). Our LIBS 2000 + has four spectrometer modules to provide high resolution (FWHM 0.1 nm) in the 200–620 nm wavelength region. The detector has a gated CCD camera with 14,336 pixels. The LIBS emission spectra are recorded at a 45° angle to the direction of incident laser pulse. Software built in the spectrometer reads the data from the chip and reconstructs the spectrum. This makes it possible to measure a large wavelength range (200–620 nm) simultaneously with high spectral resolution (0.1 nm). The software provides element identification through a spectral database for qualitative measurements. Samples can be quickly measured and saved to log-file. Options allow customization of spectral search algorithms. Custom compound element libraries can be created or searched using LIBS 2000+ spectrometer. A Q-switched Nd-YAG laser (Spectra Physics Model GCR 100) operating at 1064 nm wavelength was employed as an excitation source. It can deliver maximum pulse energy of 1 J with a pulse width of 8 ns and operates at a 10 Hz pulse repetition rate. The collimated beam at 1064 nm is tightly focused on the target sample using a convex lens to create a spark or breakdown in the sample. The laser energy was measured with a calibrated energy meter (ophir model 300) for the study of dependence of LIBS signal on incident laser energy. In this experiment, we placed a 2 mm

diameter aperture inside the path of laser beam in order to get a uniform beam shape. The pulse energy utilized in this experiment was in the range of 100–135 mJ. A lens of 25 mm diameter and 35 mm focal length was used to focus the laser beam on the lipstick samples under investigation. The exposed area on the sample was about 150 μm in diameter.

2.2. Samples preparation and the reagents used for LIBS and ICP analysis

The four lipstick samples were obtained from different cosmetic shops in the Kingdom of Saudi Arabia. These samples were of different qualities and brands with different price range. As we know that the lipstick is in the form of a fluid which required prior treatment to analyze using LIBS technique. The samples were therefore heated first for removal of any extra water contamination at 105 °C and then frozen in the refrigerator and then cut into small circular pieces of 1 cm diameter so that they fit into the sample disk holder. This holder was mounted on rotary table inside the LIBS chamber to avoid the ablation of the samples from the same spot. The emitted spectra were then recorded from these four samples. For the analysis of lipstick samples using ICP technique, standard preparation method 3050B as recommended by EPA for ICP analysis was adopted [25]. For this purpose, the contaminated lipstick samples were digested in 5% nitric acid of 99.99% purity supplied by Fisher Scientific, USA. For the digestion of samples, a representative 1 g of lipstick contaminated sample was digested with repeated additions of nitric acid (HNO_3) and hydrogen peroxide (H_2O_2). The resultant digestate is reduced in volume while heating at 95 °C for six hours and then diluted to a final volume. The resulting solution of the sample was analyzed for various metals using Inductively Coupled Plasma Spectrometer calibrated using reference standards. In order to test the homogeneity of our samples, several LIBS measurements were performed at different locations on the surface of the contaminated lipstick samples. Analytical-reagent grade chemicals without further purification were used for the calibration and analysis of lipstick samples by ICP and LIBS method. For calibration purposes, the metals used are lead, chromium, cadmium and zinc. For the construction of the calibration curves, different samples comprising these metals were prepared in lipstick matrix. For this purpose, the lipstick used as base material was having minimum contamination (lower than our detection limits) as verified by standard method like ICP. The heavy metals were in powder forms procured from Fisher Scientific USA and were of high purity (99.99%). The grain size of these metals was in the micron to sub-micron range. In order to prepare the standard samples in different concentrations, 5 g of base matrix material was mixed with heavy metals in different mass ratios at 124 °C to ensure a good mixing and homogeneity. For preparation of each sample in standard concentration, fresh sample in different mass ratio was prepared to avoid any ambiguity which could occur during sequential dilutions.

3. Results and discussion

The detection limit of any analytical instrument should be enough to detect the trace amounts of individual elements present in the sample. This detection limit can vary greatly, according to the transitional strength of the elemental line, delay time (time between the firing of the laser pulse and the opening of the camera shutter) and the gate width (time for which the shutter is open) selected during the measurements, the sample matrix, and collection optic geometry, etc. Experiments were performed to find optimal conditions of temporal delay, incident laser energy to achieve best detection limit prior to the analysis of different lip-

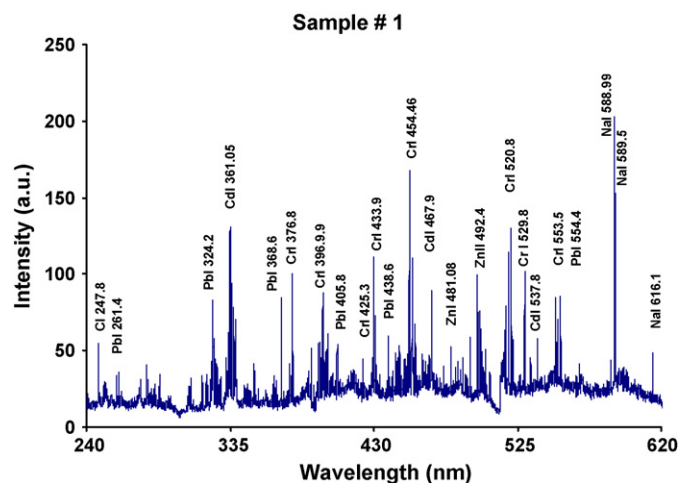


Fig. 2. Typical LIBS spectra of lipstick sample #1 purchased from local Saudi market in the region of 240–620 nm recorded at delay time of 2.0 μs and laser pulse energy = 130 mJ.

stick samples under investigation. LIBS spectra of different lipstick samples were recorded over a 240–620 nm wavelength range for qualitative and quantitative analysis.

Figs. 2–5 depict the emission spectra of lipstick samples recorded at a 2.0 μs time delay. The laser pulse energy was fixed at 130 mJ. The distance between the optical fiber and the plasma was 10 mm. The LIBS spectra of the lipstick samples were recorded to identify each element present in lipstick sample. The most sensitive lines (finger print wavelength) for identification of elements were found between 240–620 nm region using NIST database and reference [26]. The finger print wavelength (as specified in Table 1) for each element of interest was selected to study the effect of different experimental parameters. These selected finger print wavelengths were 428.9 nm for Cr, 405.8 nm for Pb, 361.1 nm for Cd and 334.5 nm for Zn. The wavelengths for all these elements are indicated on the spectrum (Figs. 2–5) and are listed in Table 1. For each data point, an average spectrum for 20 laser pulses was recorded. The recording of the averaged spectra reduces the background noise to a great extent as compared to the single shot spectrum of the sample. (Figs. 2–5) depict the typical spectrum recorded with our setup for the lipstick samples no 1, 2, 3, 4 in the 240–650 nm region.

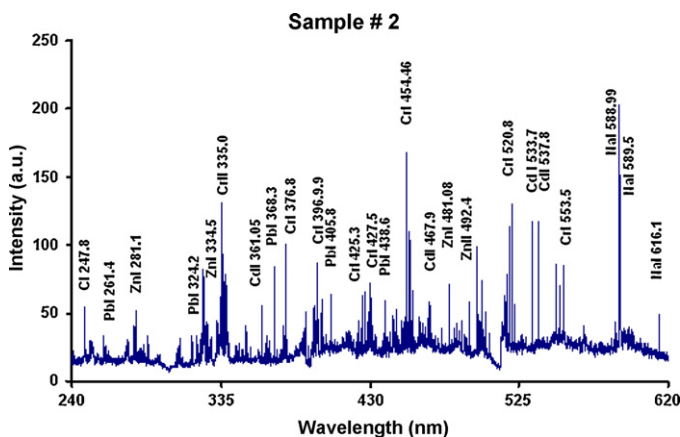
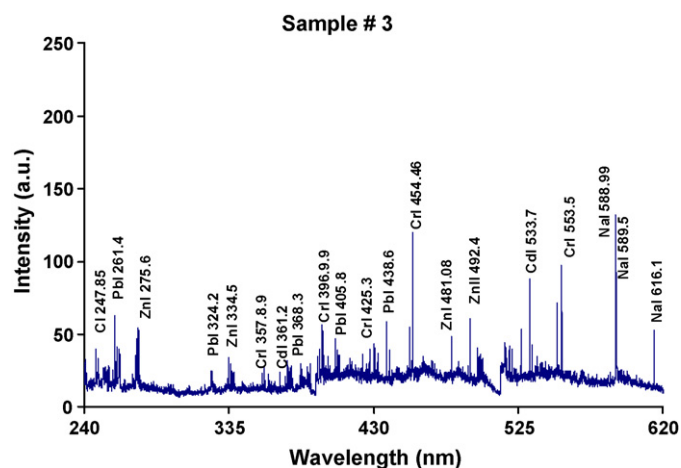


Fig. 3. Typical LIBS Spectra of lipstick sample #2 purchased from local Saudi market in the region of 240–620 nm recorded at delay time of 2.0 μs and laser pulse energy = 130 mJ.

Table 1

Toxic elements detected in lipstick samples collected from local Saudi market and comparison of LIBS with ICP results.

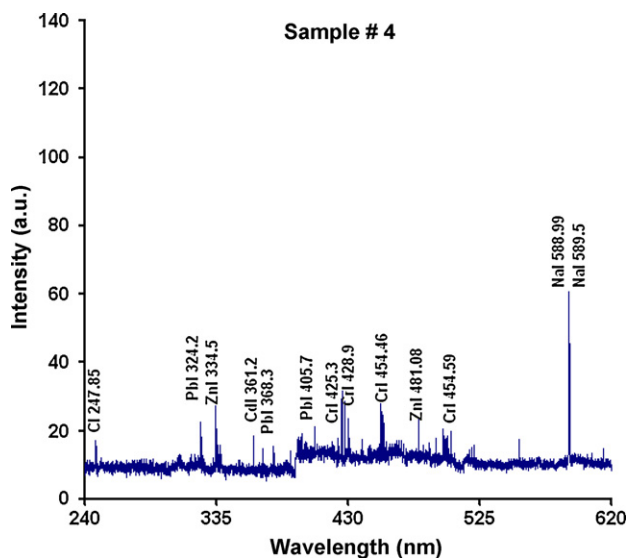
Element	Finger print wavelength	Sample #1 (unbranded, made in China)		Sample #2 (unbranded, made in India)		Sample #3 (lip care brand)		Sample #4 (Rouge Allune Luminous Satin brand)	
		LIBS (ppm)	ICP (ppm)	LIBS (ppm)	ICP (ppm)	LIBS (ppm)	ICP (ppm)	LIBS (ppm)	ICP (ppm)
Cd	361.1	10.4	9.72	10.3	9.1	9.2	10.6	4.9	5.4
Cr	428.9	40.8	39.4	17.8	16.5	16.1	17.3	10.2	9.3
Zn	334.5	14.7	12.7	14.6	12.6	14.2	12.3	8.9	7.7
Pb	405.8	8.1	8.6	9.4	9.9	7.2	6.8	5.7	6.4

**Fig. 4.** Typical LIBS Spectra of lipstick sample #3 purchased from local Saudi market in the region of 200–620 nm recorded at delay time of 2.0 μ s and laser pulse energy = 130 mJ.

3.1. Calibration curves for elements under investigation

If the energy levels of two atomic or ionic states are in local thermodynamic equilibrium (LTE), then population density of upper level N_j is related to ground level number density (N) by the Boltzmann equation [15].

$$N_j = Ng_j Q^{-1} \exp\left(-\frac{E_j}{kT}\right) \quad (1)$$

**Fig. 5.** Typical LIBS Spectra of lipstick sample #4 purchased from local Saudi market in the region of 200–620 nm recorded at delay time of 2.0 μ s and laser pulse energy = 130 mJ.

Here g_j and E_j are the statistical weight and energy of upper level j respectively, Q is the partition function of relevant species, K is the Boltzmann's constant, and T is the electron temperature of the plasma. The total intensity of a spectral line ' I ' from an excited atom or ion in homogenous and optically thin plasma for a transition from state $j \rightarrow i$ is given by [15].

$$I = hv_{ji} A_{ji} N_j \quad (2)$$

where (ν_{ji} = frequency of the transition from state $j \rightarrow i$; A_{ji} = Einstein coefficient for spontaneous emission; N_j = population of the upper level j ; h = Planck's constant.

So from above two equations, we get

$$I = hv_{ji} A_{ji} Ng_j Q^{-1} \exp\left(-\frac{E_j}{kT}\right) \quad (3)$$

From Eq. (3), one can determine the population density of the relevant species (atoms or ions) for an element in plasma from a measurement of the absolute intensity of corresponding transition and the knowledge of the excitation temperature and atomic constants. However it is not possible to derive a theoretical expression relating N and the concentration of the particular element (in lipstick sample) under investigation. Hence, in practice, an empirical relationship is required between the observed line intensity (I_j) and corresponding concentration (C), i.e.

$$I_j = F(C) \quad (4)$$

Here $F(C)$ is called analytic calibration function and the graph between the LIBS intensity of a line of specific element and the concentration is called the calibration curve.

In this experimental work, four samples of known concentration in different weight percents (wt.%) of elements (Pb, Cr, Cd, Zn) under investigation were prepared in the matrix of lipstick by melting the sample at 124 °C and adding the known concentration of each element (Pb, Cr, Cd, Zn, etc.). These elements were mixed to have homogenous solution then were cooled to prepare into solid pallet form. The LIBS spectra were recorded for these different concentrations of each element for its calibration. All these spectra were recorded with an average of 20 laser shots at three different locations on the sample surface. The calibration curve for each element under investigation was established by plotting the LIBS signal intensity of specific transition of each element as a function of the concentration. A typical calibration curve for Pb, Cr, Cd and Zn inside lipstick matrix are presented in Figs. 6–9, similar calibration curves were drawn for other elements under study for quantification of their concentration present in lipstick matrix.

The LIBS signal intensity showed linear dependence on the concentration of Pb, Cr, Cd and Zn in the standard samples as predicted by Eq. (1).

The line interference is the most problem for emission identification, thus we chose those lines for analysis which are free from interference or those which have minimal effects to get accurate results.

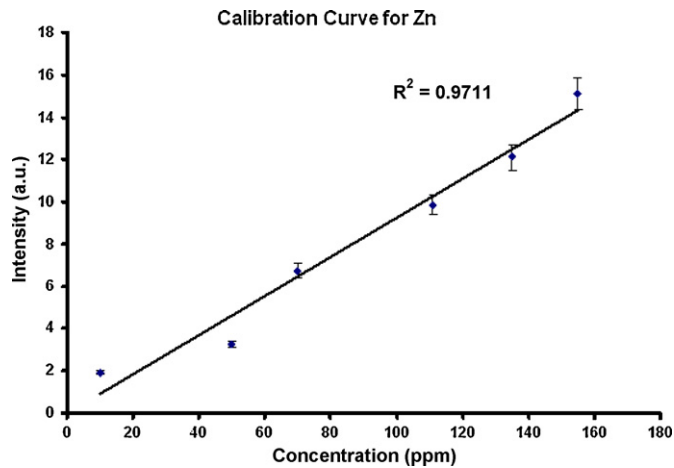


Fig. 6. Calibration curve for Zn obtained by using standard samples of zinc with known concentration.

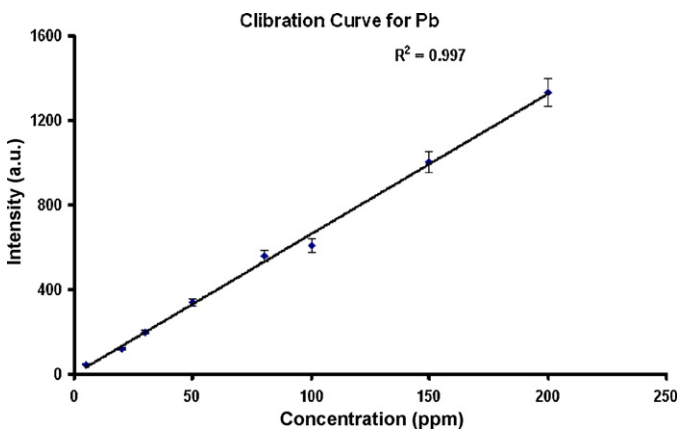


Fig. 7. Calibration curve for Pb obtained by using standard samples of Lead with known concentration.

3.2. Concentration of different toxic contaminants detected with LIBS and ICP in lipstick samples

After calibration of our LIBS spectrometer, the concentration of each element was determined with our LIBS setup which is listed in Table 1 and has been confirmed by the analysis using standard analytical technique such as ICP. The values obtained with our LIBS setup are in agreement with the ICP results as shown in Fig. 10.

The concentration of lead measured with our system is in the range of 5.7–9.4 ppm which is quite high as compared with the

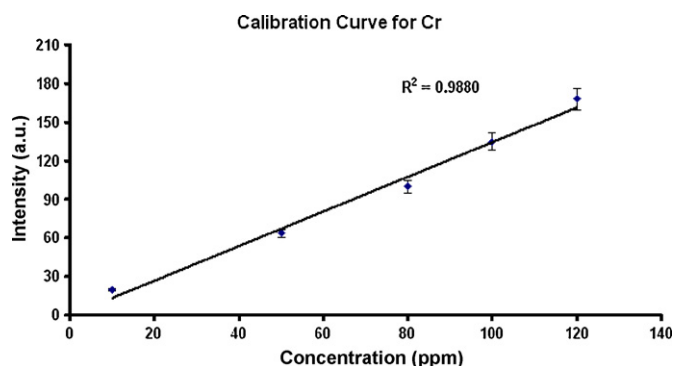


Fig. 8. Calibration curve for Cr obtained by using standard samples of Chromium with known concentration.

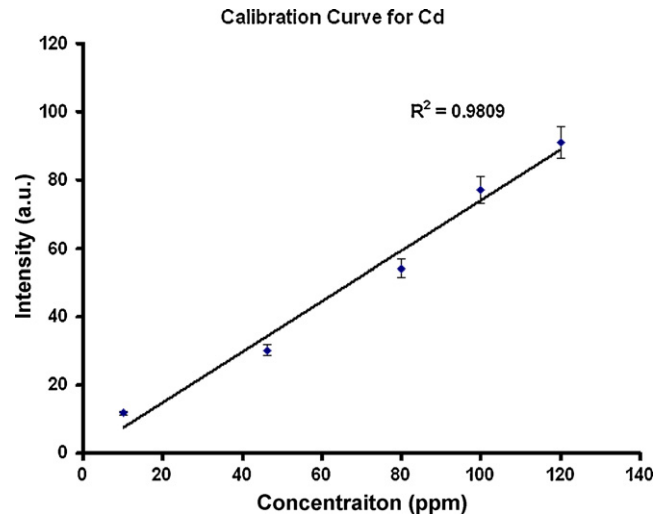


Fig. 9. Calibration curve for Cd obtained by using standard samples of Cadmium with known concentration.

safe permissible limit of 0.5 ppm set by EPA [27] and other regulatory authorities. The highest value of Pb = 9.4 ppm was detected in the cheapest priced sample of lipstick. Lead could be found in the lipstick due to the use of lead chromate in the lipstick production process. Lead could be found in the effluent in the following forms such as: Pb^{2+} , $PbCr_2O_7$ (the solubility of lead dichromate is very high), $PbCrO_4$ (pigment, the solubility of lead chromate is low, about 7×10^{-6} g/100 g water) and $Pb(OAc)_2$ (the solubility of lead acetate is very high and is about 55 g/100 g water). However LIBS system cannot distinguish between these different forms of lead and could detect only the elemental compositions of trace metals present in the test samples. Similarly for chromium; the maximum permissible limit is 1 ppm and the detected value in the lipstick samples was in the range 10.2–40.8 ppm. This high concentration of chromium in the lipstick is found due to the used of Lead chromate which is used in the pigment manufacturing process. The highest value of Cr = 40.8 ppm was detected in the cheapest priced sample of lipstick.

The safe permissible limits for Pb, Cd, Cr for water and other food products are 15, 5 and 100 parts per billions [28,29] while the concentration detected in this study in various lipstick samples listed in Table 1 is much higher than these safe permissible limits which are matter of great concern. It is worth mentioning that LIBS spectrometer developed at our laboratory and the standard method like ICP applied for comparative study are both elemental analysis

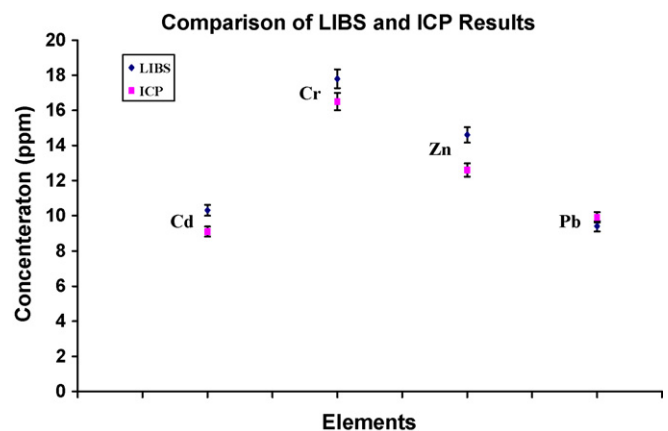


Fig. 10. Comparison of concentration of different elements detected with LIBS and ICP in Lipstick sample # 2.

Table 2

Toxic elements detected in lipstick sample #2 with the limit of detection and maximum detected concentrations and maximum permissible concentration safe limit (MPC).

Elements detected in lipstick sample #2	Wavelength (nm) ^a	Comparison of LIBS and ICP and relative accuracy (RA)			Standard deviation (S.D.) LIBS	Limit of detection of LIBS (ppm) for lipstick sample	Maximum detected concentration in LIBS (ppm)	(MPC) ^b safe limits (ppm)
		LIBS (ppm)	ICP (ppm)	RA				
Cd	361.1	10.3	9.1	0.5	1.1	2.0	10.4	0.5
Cr	428.9	17.8	16.5	0.2	0.9	2.3	40.8	1
Zn	334.5	14.6	12.6	0.3	1.1	2.6	14.7	–
Pb	405.8	9.4	9.9	0.3	0.9	1.73	9.4	0.5

^a NIST database and reference [26].^b US Food and Drug Administration (FDA) and European Food Safety Authority (EFSA).

techniques and one could not predict the complex nature of these metals present in lipstick matrix. For such studies different other spectroscopic techniques are already available which, is not the purpose of this study.

3.3. Limit of detection

The determination of the detection limit is very important for samples under investigation. Detection limit here means the lowest concentration that can be detected with our LIBS system. The detection limit (LOD) of LIBS system can be estimated using the equation [15].

$$\text{LOD} = \frac{2 \sigma_b}{S} \quad (5)$$

where σ_b is the standard deviation of the background and S is the sensitivity which is given by the ratio of the intensity to the concentration. The detection limit for LIBS analysis of lipstick samples under investigation was calculated by using the above mentioned equation. The relative standard deviation (R.S.D.) is given by the equation:

$$\text{R.S.D. (\%)} = \frac{\text{standard deviation}}{\text{mean}} \times 100 \quad (6)$$

The relative standard deviation decreased with the number of shots but no improvement in R.S.D. was noticed after 20 laser shots. The R.S.D. value in our case was 3.4%. The lipstick samples results with LIBS method were comparable to the results obtained by inductively coupled plasma emission spectroscopy (ICP). The limit of detection for some elements under investigation is given in Table 2. In this study, the limit of detection calculated using above mentioned method for lead was found to be around 1.7 ppm, for chromium to be 2.3 ppm, for cadmium to be 2.0 ppm which are higher than safe permissible limit and therefore LIBS might not be a technique of choice for the assessment of safety limits.

3.4. Comparison of the data from two detection systems and the accuracy of LIBS

The accuracy and precision for the lipstick sample under investigation obtained from these two detection systems (LIBS and ICP) are compared in table [2]. The relative accuracy (RA) is calculated as follows [30]:

$$\text{RA} = \frac{|d| + \text{S.D.} \times t_{0.975} / \sqrt{n}}{M} \quad (7)$$

where d is the difference between the LIBS measurement and the ICP (standard method). S.D. is the standard deviation of LIBS measurement, M is the measurement from standard ICP method, n is the number of measurements and $t_{0.975}$ is the t value at 2.5% error confidence. As clear from Table 2, the relative accuracy is in the range of 0.24–0.48 which is quite acceptable for any good instrument.

In order to achieve the better accuracy and precision with our method, following additional precautions were undertaken. Few

laser shots were applied to clean the sample surface prior to actual measurements identified using the NIST Atomic Data Base for neutral and ionized elements and reference data book [26]. Fluctuation of laser pulse was also considered during the performance of the experiment for betterment of precision and accuracy. In order to overcome this problem, sufficient warm up time was permitted for the laser to be stabilized prior to the start of the measurements. In addition to stabilization of laser energy over longer periods of time, the LIBS spectra were averaged for 20 laser pulses. The variation in LIBS signal intensity was stabilized by averaging for different laser shots while the relative standard deviation (R.S.D.) decreased with the increasing of number of laser shots.

The precision of any analytical instrument is defined as the repeatability of the analyte measurement, and is usually estimated in LIBS with the relative standard deviation (R.S.D.) described in Eq. (6).

For lipstick samples, the precision of LIBS measurements depends on the complexity and homogeneity of the sample, and the reproducibility of the laser shots. Typical values for LIBS are in the range of 1–7% [10–14]. For precision of our results for the four lipstick samples, the same method was adopted as applied for the analysis of samples like paint and ore samples [9,13] the precision was found to be 2–5%.

4. Conclusions

In conclusion, the concentration of various toxic carcinogen contaminants (lead, chromium, cadmium and zinc) present in the lipstick samples collected from local markets of Saudi Arabia was measured using our LIBS system. The important findings of this study are that the concentration of some of the toxic species like lead, chromium, and cadmium are much higher than the safe permissible limits, which is a matter of grave concern especially in unbranded lipstick samples. This data indicate that the continuous use of these cosmetics could result in an increase in the trace metal levels in the ocular system and the human body beyond acceptable limits. The application of these cosmetics needs to be considered as a source of lead, cadmium, chromium in evaluating patients with symptoms of lead intoxication in Saudi Arabia. The sensitive lines for the above mentioned contaminants were identified using standard data published by NIST for the elemental analysis and the calibration curves, which were effective in quantifying the concentration in different lipstick samples. The concentrations of toxic contaminants measured with our LIBS setup are in close agreement with the results achieved with a standard method such as inductively coupled plasma spectrometer (ICP). The experience gained through this work can be useful for the development of in situ LIBS system for analysis of lipstick samples in the cosmetic shops and lipstick manufacturing industries. This will ensure lipstick quality and keep a check on the safe chemical limits for consumer usage, protecting public health in the long term.

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