

# Chemistry and Cosmetics: Analysis of Lipstick for Toxic Elements Using ICP-MS



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## Abstract

Evidence of the use of cosmetics, including lipstick, has been found in civilizations as early as ancient Mesopotamia. Many of the cosmetics used throughout history have contained potentially toxic elements and other contaminations. Ancient Egyptians used cosmetics containing large amounts of lead and mercury. Modern cosmetics are perceived to be free of dangerous toxins due the widespread regulation of many consumer products. The FDA, which oversees the regulation of cosmetic products, does not have regulations governing the level of toxic or dangerous contaminants in products such as lipsticks. The FDA regulates limits on compound concentrations of additives and colorants but no overall regulation is in place for the finished product's level of potential contamination.

Previous studies have found levels of lead up to 3 ppm in lipstick. The purpose of this study was to re-examine the potential for lead contamination in lipstick and determine if any other potentially toxic metals were present in these lipsticks. Fifty-six lip products including lipsticks, lip glosses, moisturizing sticks, and lip stains were tested for the presence of toxic elements by ICP-MS.



## Materials

### Spex CertiPrep Standards:

- CLMS-1: Multi Element Solution Standard 1
- CLMS-2: Multi Element Solution Standard 2
- CLMS-3: Multi Element Solution Standard 3
- CLMS-4: Multi Element Solution Standard 4

### Reagents:

- High Purity Nitric Acid
- High Purity Hydrofluoric Acid
- 4% Boric Acid Solution

### Samples:

- Sixty Lipstick samples donated by SPEX CertiPrep employees
- Lipstick price ranges for samples was between \$10 and \$30 per container

## Sample Preparation

### Sample Preparation

Samples digested in CEM Mars 5 Microwave Unit XP-1500 Vessels using a two-step microwave digestion procedure.

#### Step 1:

- 0.3 g of sample was added to the vessel with 7 mL high purity Nitric Acid and 2 mL high purity Hydrofluoric Acid
- Microwave Program:
  - Ramp to 130°C over 15 minutes; hold 3 minutes
  - Ramp to 200°C over 15 minutes; hold 30 minutes
  - Allow to cool

#### Step 2:

- 30 mL of 4% high purity Boric Acid solution to each cooled vessel
- Microwave Program:
  - Ramp to 170°C over 15 minutes; hold 10 minutes
  - Samples diluted to 50 mL volume with Double Deionized H<sub>2</sub>O
- Digestion blanks run on each vessel prior to sample digestion
- Samples were further diluted prior to ICP-MS analysis: Final solution analyzed at approximately 1000x dilution

### Instrument Conditions

- Macroelement analysis performed on PerkinElmer ICP-OES Optima 7300
- Trace element analysis performed on Agilent ICP-MS 7700 using Meinhard nebulizer with cyclonic spray chamber
- The ICP-MS analysis was performed under normal mode using air and a collision mode using Helium

#### Instrument Conditions:

Condition	ICP-MS Agilent 7700
Power	1550 W
Plasma Gas	15 L/min
Aux Gas	0.3 L/min
Nebulizer Gas	0.80 L/min
Sampling rate	0.3 mL/min

#### Masses Examined:

Element	Gas	Mass Examined
Ag	Air	107, 109
Al	Air & He	27
As	He	75
Au	Air	197
Ba	Air	135, 137, 138
Be	Air	9
Cd	He	111, 113
Ce	Air	140
Co	Air	59
Cr	Air & He	52 & 53
Cs	Air	133
Fe	Air	57
Ge	Air & He	72, 74
Hf	Air	178, 179, 180
Hg	Air	199, 200, 201, 202
K	Air	39
Mg	Air	24, 25, 26
Na	Air	23
Ni	Air & He	60
Pb	Air	206, 207, 208
Pd	Air	105, 108
Pt	Air	194, 195, 196
S	Air	34
Sb	Air	121, 123
Si	Air	30
Sn	Air & He	117, 118, 119, 120
Sr	Air & He	86, 88
Th	Air	232
Tl	Air	47, 48, 49
Ti	He	203, 205
U	Air	238
V	He	51
Zn	Air	68



## Results

Element	Lipstick Min (ppm)	Lipstick Mean (ppm)	Lipstick Max (ppm)
Ag	ND	0.0448	0.2103
Al	4.60	6316.98	12488.72
As	0.0294	0.2216	0.8848
Au	ND	0.0045	0.0816
Ba	0.1265	2802.50	26494.60
Be	ND	0.4707	1.17
Cd	ND	0.0073	0.0439
Ce	ND	0.1029	0.6170
Co	ND	0.0971	0.6476
Cr	0.0591	2.22	31.45
Cs	ND	1.67	4.61
Fe	1.89	3435.27	27725.26
Ge	ND	0.1651	0.5836
Hf	0.0037	0.0807	0.2745
Hg	ND	0.0334	0.0846
K	0.3098	3255.63	5958.90
Mg	5.06	381.90	4676.56
Na	4.42	338.00	748.74
Ni	ND	1.71	23.36
Pb	0.0609	0.9932	2.39
Pd	0.0042	0.0245	0.0601
Pt	0.0009	0.0140	0.2345
S	94.93	1426.45	3438.87
Sb	ND	0.3935	9.58
Si	1499.13	8552.61	18217.22
Sn	0.0137	27.64	359.28
Sr	ND	16.67	109.24
Th	0.0024	0.0440	0.2130
Ti	7.16	11645.80	33704.67
Tl	ND	0.0738	0.2135
U	ND	0.0076	0.0478
V	ND	2.78	36.43
Zn	ND	0.9103	10.02

### Toxic Elements

- Potentially toxic metals examined in lipstick included: As, Be, Cd, Ce, Cs, Hg, Pb, Sb, Th, Ti, U, V and Zn
- The highest concentration levels of As and Be approached 1 ppm
- The highest concentration of Cs and Pb approached a maximum of 5 ppm
- Pb levels in samples ranged from 0.06 to 2.4 ppm - previous studies cited levels up to 3 ppm
- The maximum Sb level was almost 10 ppm
- The highest V level was over 35 ppm
- Toxic elements such as Cd, Hg, Th, Ti, U contained maximum concentration levels under 0.25 ppm

### Color Groupings

- Lipstick samples were grouped into nine color categories: White/Clear, Light Pink, Dark Pink, Mauve, Red, Coral/Peach, Wine/Berry, Beige, and Browns
- As & V levels were found to be highest in the wine/berry color grouping and the lowest in the clear/white grouping
- Be, Cs, Hg, Ti levels were highest in the coral/peach grouping and lowest in the clear/white grouping
- Ce & U levels were highest in pink groups and lowest in clear/white grouping
- Overall, the highest concentrations for the toxic metals were found in the darker lip colors; light colors, whites, and colorless products had lower toxic element concentrations

## Conclusions

### Toxic Element Exposure

- The average amount of lipstick applied to the lips ranges from 100 µg to 250 µg per application. The average lipstick container has about 3 g of product
- A poll of women who use lipstick on a daily basis suggests that a woman applies or reapplies her lipstick between four and eight times in a day
- A maximum exposure of about 1000 µg or 0.1 grams per day was calculated on the average responses
- The EPA and WHO limits for different elements were calculated for what has been reported as the average weight of an US adult female (163 lbs or 74 kg)



Element	EPA or WHO RfD µg/kg/day	Calculated RfD for 150-lb (74 kg) Adult Female (µg/kg/day)
As	4	296
Ba	200	14800
Be	2	148
Cd	1	74
Cr	3	222
Hg	0.1	7.4
Ni	20	1480
Pb	3.6	266.4
Sb	0.4	29.6
Sr	600	44400
Tl	0.1	7.4
U	3	222
V	9	666
Zn	300	22200

- The maximum toxic exposure of any of the potentially toxic elements with defined limits was well below the established limits for those elements
- The exposure of a woman to Cd, Zn or U from maximum lipstick application was 0.0006% of allowable daily intake
- The exposure to As, Be, Pb and Sr for an average woman was less than 0.009% of a daily intake limit. The exposure to Hg, Ni, Tl, and V was less than 0.06% of the daily limit
- The highest potential exposures were from Cr (0.14%), Sb (0.32%) and Ba (1.79%) of daily limits. Cr limits are established for Cr VI; this study only calculated total Cr
- Overall the amounts of lipstick that would have to be consumed in one day to exceed RfD limits far exceeded the typical daily application
- In the case of Pb, which was of concern in other studies, over 100 g or 33 tubes of lipstick would need to be consumed in a day to exceed the RfD limit

Element	Max Concentration in Lipstick (µg/g)	µg in 0.1 g lipstick	% Daily Intake Limit from Lipstick	Amount needed to exceed RfD (g)
As	0.88	0.0088	3.0E-03	334.54
Ba	26494.60	264.9460	1.79	0.56
Be	1.17	0.0117	7.9E-03	126.28
Cd	0.04	0.0004	5.9E-04	1684.66
Cr	31.45	0.3145	0.14	7.06
Hg	0.08	0.0008	1.1E-02	87.49
Ni	23.36	0.2336	1.6E-02	63.35
Pb	2.39	0.0239	9.0E-03	111.39
Sb	9.58	0.0958	0.32	3.09
Sr	109.24	1.0924	2.5E-03	406.43
Tl	0.21	0.0021	2.9E-02	34.66
U	0.05	0.0005	2.2E-04	4639.80
V	36.43	0.3643	5.5E-02	18.28
Zn	10.02	0.1002	4.5E-04	2216.03