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국내 유통 어린이 및 무기 자외선차단제에서 자외선 차단성분, 보존제 및 중금속 실태 조사

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A Study on UV Filters, Preservatives and Heavy Metals Contained in the Children's and Inorganic Sunscreens Distributed in Korea

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요 약: 본 연구에서는 국내 유통 중인 민감성 피부 대상 자외선 차단제의 안전성 조사를 위해 무기 자외선 차단제 27 건 및 어린이용 자외선 차단제 23 건을 수거하여 자외선 차단 성분 17 종, 보존제 13 종 및 중금속 5 종의 사용 및 혼입 실태를 조사하였다. 그 결과 자외선 차단 성분은 티타늄디옥사이드(41 건), 징크옥사이드(29 건), 비스-에칠헥실옥시페놀메톡시페닐트리아진(10 건) 에칠헥실살리실레이트(8 건) 및 에칠헥실메톡시신나메이트(8 건)순으로 검출되었으며, 보존제는 페녹시에탄올(6 건), 안식향산(1 건), 디히드로초산(1 건) 순으로 검출되었다. 확인된 자외선 차단성분은 모두 표시 사항에 적합 하였으나, 1 개 제품에서 표시사항 외 보존제 성분인 페녹시에탄올이 0.1% 농도로 검출되었다. 중금속 납, 카드뮴, 비소, 안티몬, 니켈은 불검출에서 3.6 μg/g로 다양한 농도로 검출되었다. 이번 연구에서 확인된 자외선 차단성분, 보존제 및 중금속은 화장품 안전기준 등에 관한 규정의 성분별 최대 배합한도 및 최대 허용량 기준에 적합하였다.

Abstract: In this study, 27 inorganic sunscreens and 23 sunscreens for children were collected to investigate the use and incorporation of 17 types of sunscreen agents, 13 types of preservatives, and 5 types of heavy metals. As a result, sunscreen agents were detected in the order of titanium dioxide (41 cases), zinc oxide (29 cases), bis-ethylhexyloxyphenyltriazine (10 cases), ethylhexyl salicylate (8 cases), and ethylhexylmethoxynamate (8 cases), and preservatives were detected in order of phenoxyethanol (6 cases), benzoic acid (1 case), and dihydroacetic acid(1 case). All of the identified sunscreen agents were suitable for labeling, but phenoxyethanol, a preservative component other than labeling, was detected at a concentration of 0.1%. Heavy metals such as lead, cadmium, arsenic, antimony, and nickel were not detected or were detected at various concentrations of less than 3.6 μg/g. All the detected UV filters, preservatives, and heavy metals were less than the allowed maximum amount stipulated by the Regulations on Cosmetic Safety Standards in Korea.

Keywords: *sunscreen for Children, inorganic Sunscreen, UV Filter, preservative, heavy metals*

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1. Introduction

Sunscreens protect the human body from various skin diseases such as skin aging, allergies, and skin cancer caused by ultraviolet (UV) rays. As a number of sunscreens have recently been used for the purpose of cosmetics as well as for UV protection, the production of sunscreens is continuously increasing[1,2]. According to the Korea Health Industry Development Institute (KHIDI), the amounts of sunscreen production in Korea in 2019 reached 595.5 billion won, compared to 393.4 billion won in 2015, the increase of 254.7 billion won, the rise to 51.4% over four years[3].

UV filters in sunscreens are divided into organic UV filters that absorb UV rays and release them as heat according to their mechanism of action, and inorganic UV filters that reflect UV rays by physically covering the surface of the skin. Organic UV filters contain oxybenzone (benzophenone-3) and avobenzone (butyl methoxydibenzoylmethane). Inorganic UV blocking components contain zinc oxide and titanium dioxide. Most sunscreens are produced and sold as mixing organic UV filters and inorganic UV filters for reasons such as its efficacy, effectiveness, safety, and ease of use[4].

Some of the organic UV filters, such as benzophenone-3, 4-methylbenzylidene camphor, have side effects that cause skin irritation and inhibition of reproductive cell development. Accordingly, the US FDA emphasized the safety of sunscreens, suggesting the use of inorganic UV filters, such as zinc oxide and titanium dioxide to block ultraviolet rays. In addition, from January 2021, Hawaii has initiated a law regulating the use of sunscreens containing benzophenone-3 and ethylhexyl methoxycinnamate, functioning as organic UV filters, on the coast to protect the marine environment[5,6].

Sunscreens are managed as functional cosmetics in Korea, but there are concerns about the safety of consumers when using sunscreen products. According to a survey on the awareness and use of sunscreen products for children in Korea, 60.5% of the respondents who hesitated if their children would use the sunscreens said that the product was regarded as having the bad effects on the skin. Thirty nine percentage of those who did not have the sunscreens used by their children said that they were likely to cause skin irritation[7,8].

Recently, in response to the needs of consumers, various sunscreens such as inorganic sunscreens that do not contain organic UV filters and sunscreens for children that do not contain preservatives have been developed and released. In particular, these products are promoted and sold for those who are sensitive to skin irritation, so more precise quality control is required.

In this study, in order to investigate whether the sunscreens for sensitive skin meet the cosmetic safety standards and the actual condition, and to evaluate the safety, we collected commercially available sunscreens for children and inorganic sunscreens. We investigated the amounts of UV filters, preservatives and heavy metals, whether they consumed are complied with the allowed amounts, and whether or not the sunscreen contains UV filters and preservatives other than the ingredients listed in the sunscreens.

2. Experimental Methods

2.1. Samples

We collected 23 sunscreens for children and 27 inorganic sunscreens, which are commercially available sunscreens for sensitive skin type. In accordance with the regulations on cosmetic safety standards, 17 types of UV filters, 13 types of preservatives, and 5 types of heavy metals were tested. The 17 types of UV filters were selected, based on the amount used and the harmfulness of the skin.

2.2. Instruments and Reagents

In this study, UV filters octocrylene, menthyl anthranilate, ethylhexyl salicylate, homosalate, butyl methoxydibenzoylmethane, benzophenone-3 (oxybenzone), benzophenone-4 (sulisobenzone), benzophenone-8 (dioxybenzone), ethylhexyl methoxycinnamate, phenylbenzimidazole sulfonic acid, 4-methylbenzylidene camphor, drometrizole, bis-ethylhexyloxyphenol methoxyphenyl triazine, and diethylamino hydroxybenzoyl hexyl benzoate were purchased from Sigma (USA). Benzyl alcohol, phenoxy ethanol, methylparaben, ethylparaben, isopropylparaben, propylparaben, benzoic acid, dihydroacetic acid, sorbic acid and were manufactured by Sigma (USA). Salicylic acid and butylparaben (USP, USA), chlorphenesin and isobutylparaben (LGC, USA) were used. Lead, cadmium, antimony, nickel, arsenic, titanium and zinc were manufactured by AccuStandard (USA).

According to the cosmetic test method of the Korea Food and Drug Administration, the content analysis of 15 organic UV filters and 13 preservatives was conducted by HPLC-DAD (2695 Alliance series, Waters, USA). Two inorganic UV filters and five heavy metals were analyzed using an ICP-OES (OPTIMA 8300, Perkin Elmer, USA).

2.3. Methods

2.3.1. Organic UV filters

The organic UV filters were divided into 4 groups.

Group 1. Octocrylene, menthyl anthranilate ethylhexyl salicylate, homosalate, and butyl methoxydibenzoylmethane were accurately set as the standards 10 mg, respectively, and then were dissolved in 100 mL methanol to make a stock solution. Approximately 1.0 g of the samples were precisely weighed and dissolved in 50 mL of methanol.

Group 2. In the case of benzophenone-3, benzophenone-4, benzophenone-8 and ethylhexyl methoxycinnamate, they were accurately measured as the standards of 100 mg, respectively, and then were dissolved in 83% of 10 mL methanol to use as a stock solution. Approximately 1.0 g of the samples were precisely weighed and dissolved in 83% of 50 mL methanol

Group 3. In the case of phenylbenzimidazole sulfonic acid, isoamyl-p-methoxycinnamate, 4-methylbenzylidene camphor, and drometrizole, they were measured as the standards of 100 mg, respectively, and then were dissolved in 100 mL methanol to obtain a stock solution. Approximately 1.0 g of the samples were precisely weighed and dissolved in 50 mL methanol. Approximately 1.0 g of the samples were precisely weighed and dissolved in 50 mL methanol.

Group 4. In the case of bis-ethylhexyloxyphenol methoxyphenyl triazine and diethylamino hydroxybenzoyl hexyl benzoate they were measured as the standards of 100 mg, respectively, and then were dissolved in 100 mL dimethylformamide to make a stock solution. Approximately 0.1 g of the samples were precisely weighed and dissolved in 50 mL dimethylformamide.

Using stock solutions, standard solution samples of the concentration rage of 1 ~ 20 mg were filtered through a membrane filter with a pore diameter of 0.45 μm. According to the HPLC method in Table 1, the working standard solutions and sample solutions were experimented. The calibration curves were drawn up with the peak area for each concentration of the standards, and the amount of UV filters detected in the

Table 1. Analysis Conditions of HPLC for Organic Ultraviolet Filters

<table>
<tr><th>No.</th><th>Column</th><th>Wavelength (DAD detectoer)</th><th>Injection volume</th><th>Flow rate</th><th colspan="3">Mobile phase</th></tr>
<tr><td>Group 1</td><td>Shiseido, Capcellpak C18 UG120
(5 μm, 4.6 X 250 mm)</td><td>300 nm</td><td>10</td><td>1 mL/min</td><td colspan="3">MeOH : 0.01 M Sodium dihydrogen phosphate
(90 : 10)</td></tr>
<tr><td>Group 2</td><td>Xterra, MS C8
(5 μm, 4.6 X 250 mm)</td><td>313 nm</td><td>10</td><td>1 mL/min</td><td colspan="3">MeOH : Water
(83 : 17)</td></tr>
<tr><td rowspan="8">Group 3</td><td rowspan="8">Shiseido, Capcellpak C18 UG120
(5 μm, 4.6 X 250 mm)</td><td rowspan="8">300 nm</td><td rowspan="8">10</td><td rowspan="8">1 mL/min</td><td colspan="3">A : MeOH,
B : 0.01M Sodium dihydrogen phosphate</td></tr>
<tr><td>Times (min)</td><td>A (%)</td><td>B (%)</td></tr>
<tr><td>0</td><td>30</td><td>70</td></tr>
<tr><td>30</td><td>100</td><td>0</td></tr>
<tr><td>30.1</td><td>100</td><td>0</td></tr>
<tr><td>35</td><td>100</td><td>0</td></tr>
<tr><td>35.1</td><td>30</td><td>70</td></tr>
<tr><td>37</td><td>30</td><td>70</td></tr>
<tr><td>Group 4</td><td>Shiseido, Capcellpak C18 UG120
(5 μm, 4.6 X 250 mm)</td><td>350 nm</td><td>10</td><td>1 mL/min</td><td colspan="3">ACN : MeOH
(55 : 45)</td></tr>
</table>

samples were calculated.

2.3.2. Inorganic UV Filters

Titanium dioxide and zinc oxide 1,000 mg/L were diluted with 0.5 N nitric acid solution to be contained in the concentration range of 0.1 ~ 5 mg/L, and used as standard solutions.

It was found that approximately 0.1 g of each sample contain 7 mL of nitric acid, 2 mL of sulfuric acid, 1 mL of hydrofluoric acid in microwave system, and that the maximum power account for 1,000 W, the maximum temperature was 200 ℃, and the decomposition time took about 55 min. The corresponding samples diluted by purified water 50 mL, and then took 1 mL of this sample and diluted 200 times to be detectable in subsequent ICP-OES analysis. Separately, a blank test solution were prepared in the same manner as the sample solution. The standard solutions and sample solutions were analyzed, using ICP-OES and 99.99 v/v% of argon for plasma gas at a wavelength of 324.199 nm for titanium and 202.551 nm for zinc.

2.3.3. Preservatives

Used were the standards of benzyl alcohol, phenoxyethanol, methylparaben, ethylparaben, isopropylparaben, propylparaben, isobutylparaben, butylparaben, benzoic acid, dihydroacetic acid, sorbic acid, chlorphenesin and salicylic acid. The standard stock solutions were accurately measured as 5 ~ 200 mg/L. The mixed standard solution of thirteen preservatives with 1 ~ 2 mg/mL of concentrations was dissolved with 50% acetonitrile containing 1% phosphoric acid. Weigh about 2.0 g of a sample precisely, add 50 mL of 50% acetonitrile containing 1% phosphoric acid, and shake it by ultrasonication to sufficiently disperse the samples. The standard and sample solutions were filtered through a membrane filter with a pore diameter of 0.45 μm. These were experimented through the HPLC method. The instrument analysis conditions are shown in Table 2. A calibration curve was prepared with the peak area for each concentration of the standard solutions, and the amount of the preservatives in the sample solution was calculated, based on this.

Table 2. Analysis Conditions of HPLC for Preservatives

Column	Shiseido, Capcellpak C18 UG120 (5 μm, 4.6 X 250 mm)		
Flow rate	1 mL/min		
Injection volume	10 μL		
Mobile phase	A : 1% phosphoric acid in 20% ACN B : 1% phosphoric acid in 70% ACN		
	Time (min)	Solvent A (%)	Solvent B (%)
	0	100	0
	8	75	25
	15	60	40
	25	40	60
	30	0	100
	37	100	0

2.3.4. Heavy Metals

The standard solution was diluted with a 0.2 N nitric acid solution from 0.025 mg to 0.5 mg in the concentrations per 1 L, based on a multi-standard with a concentration of 100 mg/mL. The samples precisely weighing 0.2g into a microwave decomposition container was added as 5 mL of nitric acid and 1 mL of hydrofluoric acid. Set the maximum power to 1,000 W, the maximum temperature to 200 ℃, and the decomposition time to about 55 min, and then adjusted the microwave condition until it turned pale yellowish at the achromatic state. After the decomposition is completed, kept the sample solutions at the room temperature, so that they are moved to 25 mL of volumetric flasks to distilled water amounting 25 mL. The same procedure as the sample was conducted, with 5 mL of nitric acid and 1 mL of hydrofluoric acid being contained in a blank test solution. The standard solutions and the sample solutions were analyzed, using ICP-OES with the wavelength of lead at 220.353 nm, cadmium at 228.802 nm, antimony at 206.836 nm, nickel at 231.604 nm, and arsenic at 193.696 nm, made of plasma gas amounting to 99.99 v/v% of argon.

3. Results and Discussion

3.1. Validation and Statistical Analysis

The limit of detection (LOD), limit of quantitation (LOQ) values and linearity of UV filters, preservatives, and heavy metals components were measured. The values were calculated through the regression analysis. It was found that the LOD values of the organic UV filters and preservatives were from 0.01 to 0.25 mg/L, and that and the LOQ value was from 0.03 to 0.76 mg/L. In the case of LOD values of inorganic UV filters and heavy metals, it was identified that they reached from 0.001 to 0.003 mg/L, and that LOQ values were from 0.004 to 0.009 mg/L. The R^2 value calculated after a calibration curve for each standard had been arranged showed a linearity amounting 0.999 or more. Student's *t*-test was conducted to analyze a statistical significance difference between comparison groups, and a chi-square test was administered to compare the detection frequency between each item. All statistical tests were verified for significance at the 95% confidence level.

3.2. UV Filters

A test result of 2 types of inorganic UV filters were identified in 27 inorganic sunscreens and 17 sunscreens for children. Titanium dioxide was detected in 41 out of 50 sunscreens, and that the detected concentration accounted for 1.2% to 14.4%. The amounts of the concentration of zinc oxide detected in 29 cases from 50 sunscreens were 0.1% to 24.5%. The detected titanium oxide and zinc oxide were all within the allowed maximum amounts (25%) and were the same as the label. As shown in Table 3, the titanium dioxide was identified in 25 out of 27 inorganic sunscreens and 16 out of 23 sunscreens for children. Zinc oxide was found in 22 inorganic sunscreens, which accounted for 81.4% of detection rate, and it was identified in 7 sunscreens for children with a detection rate of 30.4%. It was confirmed that detected sample number of zinc oxide was significantly higher in inorganic sunscreens than in sunscreens for children (chi-square test, $p < 0.05$). Zinc oxide is known to improve the skin health with its anti-inflammatory and regenerating and regenerative properties

Table 3. Analytic Results of Inorganic UV Filters

Compounds (Maximum allowed amounts (%))	Number of samples detected /Number of samples tested		Detection range (%)	
	Inorganic sunscreens	Sunscreens for children	Inorganic sunscreens	Sunscreens for children
Titanium dioxide (25)	25/27	22/23	1.2 – 12.2	1.3 – 14.4
Zinc oxide (25)	16/27*	7/23	0.4 – 24.5	0.1 – 23.5

*$p < 0.05$

Table 4. Analytic Results of Organic Ultraviolet Filters in Sunscreens for Children (N = 13)

Compounds (Maximum allowed amounts (%))	Number of samples detected	Detection range (%)
Octocrylene (10)	4	1.2 – 7.8
Menthyl anthranilate (5)	0	–
Butyl methoxydibenzoylmethane (5)	3	0.1 – 4.1
Ethylhexyl salicylate (5)	8	2.1 – 4.3
Homosalate (10)	1	7.6
Benzophenone_3 (5)	0	–
Benzophenone_4 (5)	0	–
Benzophenone_8 (3)	0	–
Ethylhexyl methoxycinnamate (7.5)	8	6.1 – 7.0
Phenylbenzimidazole sulfonic acid (4)	3	0.2 – 1.7
Isoamyl p-methoxycinnamate (10)	1	0.3
Menthylbenzylidene camphor (4)	1	1.0
Drometrizole (1)	0	–
Diethylamino hydroxybenzoyl hexyl benzoate (10)	5	2.8 – 7.9
bis-Ethylhexyloxyphenol methoxyphenyl triazine (10)	10	0.3 – 4.7

as well as UV protection[9]. Therefore, it is considered that this substance would be widely used in inorganic sunscreens for sensitive skin.

There was a test of 15 types of organic UV filters. The result showed organic UV filters were only confirmed in 13 children's sunscreens. No organic UV filter was mixed in the all inorganic sunscreens (N = 27) and the 10 sunscreens for children. Regarding 13 sunscreens for children, 10 types of organic UV filters were identified. The research findings are shown in Table 4. The most detected organic UV filters were bis-ethylhexyloxyphenol methoxyphenyltriazine (10 cases), ethylhexyl salicylate (8 cases) and ethylhexyl methoxycinnamate (8 cases), and the others were diethylamino hydroxybenzoyl hexyl benzoate (5 cases) and octocrylene (4 cases) butyl methoxydibenzoylmethane (3 cases), phenylbenzimidazole sulfonic acid (3 cases), homosalate (1 case), isoamyl p-methoxycinnamate (1 case) and menthylbenzylidene camphor (1 case). It was confirmed that 1 to 5 organic UV filters were mixed and used in one product. All of the detected organic UV filters were within the allowed maximum amounts equivalent to the labeling of the sunscreens. Also, it was identified that benzophenone-3, benzophenone-4, and benzophenone-8 were not used.

Benzophenone-based sunscreens are known to be a common cause of photoallergic reactions incurred by UV rays. For this reason, commercially available sunscreens containing benzophenone-3 that EU has been using are managed, under the terms and conditions of attaching the label to indicate the content of benzophenone-3[10].

The analytic result about UV filters in sunscreens for sensitive skin type of this study revealed that the allowed maximum amounts and the labeling were in compliance with the required terms and conditions. However, when several UV filters are mixed and used in one sunscreen, there is no safety standard for the total amount of UV filters. Taking it into account, it is considered that the relevant guidelines should be presented, in the future.

3.3. Preservative

A test of 13 types of preservatives in 50 sunscreens indicated that they were in 8 products. Among the preservatives detected were phenoxyethanol (6 cases), benzoic acid (1 case), and dehydroacetic acid (1 case), in order. No other preservative was detected (Table 5). All of the detected preservatives were within the allowed maximum amounts. One product of the six where phenoxyethanol was confirmed, no listed in the labeling information but the detected concentration was proved as 0.1%, which is believed to have originated from the raw material. It was considered that the allowed maximum of phenoxyethanol, as one of preservatives, is 1%, and the amounts of the detected phenoxyethanol are insufficient to exert a preservative effect on the finished product. According to the Enforcement Rule of the Cosmetics Act, the effect may not be raised on “Ingredients containing ancillary ingredients such as stabilizers and preservatives contained in the raw material itself and in an amount less than the amount to show the effect may be omitted.” Thus, it was considered that there was no violation of labeling requirements.

The research result of Park et al. in 2017 revealed that regarding general sunscreens distributed in Korea, the detection rate of phenoxyethanol was 61%, and the number of the use

Table 5. Analytic Results of 16 Preservatives in Sunscreens (N = 50)

Compounds (Maximum allowed amounts (%))	Number of samples detected	Detection range (%)
Phenoxyethanol (1)	6	0.1 – 0.7
Benzoic acid (0.5)	1	0.3
Dehydroacetic acid (0.6)	1	0.3
Ethylparaben (0.4% as paraoxybenzoic acid)	0	-
Methylparaben (0.4% as paraoxybenzoic acid)	0	-
Isopropylparaben (0.4% as paraoxybenzoic acid)	0	-
Propylparaben (0.4% as paraoxybenzoic acid)	0	-
Isobutylparaben (0.4% as paraoxybenzoic acid)	0	-
Butylparaben (0.4% as paraoxybenzoic acid)	0	-
Benzyl alcohol (1)	0	-
Chlorphenesin (0.3)	0	-
Salicylic acid (0.5)	0	-
Sorbic acid (0.6)	0	-

of preservatives other than the labeling ingredients also reached 31 out of 100 cases[11].

Concerning sunscreens for sensitive skin type in this study, the total preservative detection is 16%, which is a small figure compared to general sunscreens.

Ethylparaben, methylparaben, isopropylparaben, propylparaben, and isobutylparaben were not identified in all sunscreens. Parabens were the most commonly utilized for monitoring the content of preservatives in creams and cosmetics distributed by the Gyeongin Regional Food and Drug Administration in 2002[12]. Parabens have non-volatile and high antimicrobial properties. Thus, they have been widely used as preservatives in cosmetics, but the side effects such as endocrine system effects and cytotoxicity are known[13]. Taking this into allowance, it is anticipated that the consumption of parabens has been decreased. A major example is the recent trend that paraben-free cosmetics are launched.

3.4. Heavy metals

A test of the heavy metal detection amounts was administered. In the inorganic sunscreens, the average concentrations of Pb, Cd, Sb, Ni and As were 0.50 μg/g, 0.02 μg/g, 2.28 μg/g, 0.96 μg/g, and 0.02 μg/g. The detection range of each heavy metal was Pb from non-detection to 1.9 μg/g, Cd from non-detection to 0.1 μg/g, Sb from non-detection to 3.6 μg/g, Ni from non-detection to 2.5 μg/g, and As from non-detection to 0.2 μg/g.

In sunscreens for children, the average concentrations of Pb, Cd, Sb, Ni and As were 0.23 μg/g, 0.00 μg/g, 0.52 μg/g, 0.46 μg/g, and 0.01 μg/g. The detection range of each heavy metal was Pb from non-detection to 1.1 μg/g, Cd from non-detection to 0.0 μg/g, Sb from non-detection to 2.9 μg/g, Ni from non-detection to 2.8 μg/g, and As from non-detection to 0.3 μg/g. As shown in Table 6, it was confirmed that the detected average amounts of Pb, Sb, and Ni were higher in the inorganic sunscreen than in the sunscreens for children (student's t-test, $p < 0.05$).

However, all of the detected heavy metals were very low concentrations below the permissible limit. As specified in the Regulations on Cosmetic Safety Standards, the permissible limit of heavy metals in cosmetics is set and managed, when it is impossible to completely remove them. The permissible limit us as follows: 20 μg/g of Pb, 5 μg/g of Cd, 10 μg/g of Sb, Ni and As, respectively.

Cosmetics have a quick and direct effect on the human body through the skin. Thus, heavy metals should be managed through continuous monitoring, as they can be accumulated in the human body and cause serious poisoning symptoms and diseases[14].

4. Conclusion

The survey results of 27 inorganic sunscreens and 23 sunscreens for children distributed in Korea are as follows.

1. The 2 types of inorganic UV filters were contained in 27 inorganic sunscreens and 17 sunscreens for children. Regarding the 15 types of organic UV filters, 10 types of them, for examples, such as, bis-ethylhexyloxyphenol methoxyphenyltriazine were identified in 13 sunscreens for children. It was confirmed that 1-5 types of organic UV filters were mixed and used in one product. Inorganic sunscreens did not contain organic UV filters.

Table 6. Means and SD Values of Detected Heavy Metals in Sunscreens

Compounds (Maximum allowed amounts (μg/g))	Inorganic sunscreens (N = 27, μg/g)		Sunscreens for children (N = 23, μg/g)	
	Mean	SD	Mean	SD
Pb (20)	0.50*	0.27	0.23	0.11
Cd (5)	0.02	0.00	0.00	0.00
Sb (10)	2.28*	1.62	0.52	1.08
Ni (10)	0.96*	0.24	0.46	0.46
As (10)	0.02	0.00	0.01	0.01

*$p < 0.05$

All of the blended UV filters were the same as the product labeling, and that were within the allowed maximum amounts.

2. There was a test of 13 types of preservatives in 50 sunscreens. The result revealed that preservatives were detected in 8 cases, and the detection rate accounted for 16%. Given this fact, it is considered that preservatives are less used in inorganic and children's sunscreens than general sunscreens. It was confirmed that the most used preservative was phenoxyethanol, and parabens were not detected.
3. It was confirmed that the detected average amounts of Pb, Sb, and Ni were higher in the inorganic sunscreen than in the sunscreens for children. All of the detected heavy metals were low concentrations below the permitted level.

The analytic result of this study revealed that the sunscreens for sensitive skin type mainly use inorganic UV filters rather than organic UV filters, and they meet cosmetic safety standards.

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