Toxicity and Effect of Chemicals in Skin Care Products on Human Health

Wenxin Liang1,*
1Faculty of Science, Hong Kong University, Hong Kong 999077, China
* Corresponding author: 1109037678@qq.com

Abstract: Chemicals in skincare products are very critical because they not only have an influence on the safety of cosmetics but also on all aspects of the human body and life. For sensitive skin, a particular type of skin that should avoid cosmetics containing harmful chemicals, it is significant to evaluate the toxic and protective mechanism of products by using scientific methods. Besides, using the experimental data to explore the protective and toxic effects of functional skincare products on sensitive skin is more clear to clarify the pathophysiology, biochemical changes and particular clinical manifestations of skin diseases. These phenomena occur after the skin contact with chemical substances, and the dynamic process of the chemicals damages the skin barrier and percutaneous absorption. By observing the performance and improvement of sensitive skin protection before and after the experiment, the research evaluates the toxicity of the different chemical substances in skincare products on sensitive skin. The research in this article is also helpful for people to use skin care products reasonably and promote skin health.

1. Introduction of sensitive skin and cosmetics
Sensitive skin is a kind of skin with extraordinarily sensitizing and highly intolerant to any slight external irritation and is prone to itching, tingling, burning, and tightness. The clinical manifestations of sensitive skin are mainly subjective sensory abnormality, lack or slight objective symptoms, high sensitivity, poor tolerance, and strong responsiveness [1].

With the widespread use of cosmetics, various problems have also appeared, such as low quality of cosmetics, excessive levels of toxic substances, the addition of glucocorticoid-prohibited drugs, and consumers' failure to choose cosmetics based on their skin type. Hospital visits make the appearance of cosmetic dermatitis endless in the crowd. Cosmetic toxicity, in the broad sense, refers to abnormal changes in the physiological state of the skin caused by the use of cosmetics. It mainly manifests as cosmetic photodermatitis, irritating cosmetic dermatitis, cosmetic allergic contact dermatitis, cosmetic hormone-dependent dermatitis, and cosmetic pigments. Also, cosmetics may cause abnormal dermatitis and hair damage. The narrow sense of cosmetic dermatitis refers only to cosmetic allergic contact dermatitis and cosmetic irritant dermatitis [2].

In future research, there will be more studies about the pathogenesis of sensitive skin and the ingredients in cosmetics that cause the formation of sensitive skin, providing compelling evidence for the development of more sensitive cosmetics for sensitive skin.
2. Recognition of sensitive skin

2.1 Concept of sensitive skin
Sensitive skin refers to a state of skin hypersensitivity that occurs under physiological or pathological conditions. It is common in young and middle-aged people, and the disease site is mainly the face. Common symptoms of sensitive skin include flushing, erythema, itching, tingling, irritation, dryness and discomfort, desquamation, palate, fine pimples, and exudation. Patients often show heat sensitivity, sometimes even simple skincare products and water cannot tolerate, rash repeatedly and challenging to cure so that many patients show anxiety and anxiety.

The epidermis of sensitive skin is very fragile and inelastic. Although the appearance looks white and tender, it is susceptible. This kind of inherited skin is sensitive to fragrance, and many cosmetics cannot be rubbed. When the skin exposes to wind and sun, clothes are too tight, friction, impermeable substances, alcohol, the perfume will make a sensitive situation more dangerous.

2.2 Causes for sensitive skin
This hypersensitivity of the skin results from a decrease in its tolerance threshold [3]. At present, the cause is not clear, so that it may be a widespread phenomenon caused by various factors such as internal and external causes. Different factors can explain it:
- An inflammatory reaction develops when skin contact with irritating chemicals such as soaps, household detergents, or pollution.
- The altered barrier function of the epidermis. This phenomenon then promotes dehydration of the skin and especially the penetration of potentially irritating agents.
- Psychological factors like stress.
- Hormonal factors (menstrual cycle, menopause).
- Physical factors: sun, temperature changes (hot/cold), wind, air conditioning, heating, hard water.

3. The Judgment of sensitive skin
The judgment of sensitive skin can divide into subjective judgment, Semi-subjective judgment, and objective judgment according to its mechanism [4].

3.1 Subjective judgment
Subjective judgment mainly takes the form of a questionnaire. Its accuracy is affected by the design of the interviewer and the interviewee. The questionnaire should contain any information that may be relevant, such as slight damage (roughness) of the skin to dry and cold weather, sunlight, sweat, skincare products, housekeeping products, jewelry, fabrics, wool. If the facial skin is prone to redness, dryness, tingling, burning, itching, and discomfort; if people have a history of adverse cosmetic reactions, a history of dermatitis and eczema, a history of asthma or hay fever; investigators must be fully trained to master the investigation skill.

3.2 Semi-subjective judgment
The methods used for semi-subjective evaluation are skin chemical probe tests, including lactic acid test, chloroform-methanol mixed solution test, dimethyl sulfoxide test, and skin response test. There are two representative methods for testing lactic acid. In the first method, researchers apply aqueous lactate solution to the cheek and wipe with a cotton swab on the face with room temperature. In the second method, the researcher makes the subject sweat in a room with low relative humidity and then apply aqueous lactic acid to the wrinkles and nose, lips, and cheeks. Finally, researchers use sub-methods to assess the tingling of the sum. It may sound subjective, but the results are very similar to reality. It is considered highly reproducible. The test response of lactic acid is closely related to the season. For example, it is more severe in winter in summer, which indicates that the increase in skin tingling may cause by dry skin in winter. However, in winter, dry skin may lead to increased skin tingling and impaired barrier function, and highly sensitive nerve sensory signals.
3.3 Objective judgment

Objective judgment is to use biomedical engineering technology to evaluate subtle changes in the skin through non-invasive techniques. For example, the experimenter can use the water vaporizer to measure the water loss of the skin, measure the biophysical parameters of the skin, and use the ultrasonic scanner to check the thickness of the epidermis, dermis and subcutaneous tissue. In fact, measuring skin transepidermal water loss is the most classic indicator.

It is common to use human skin testing. However, other methods are also useful. Including patch test, light patch test, forearm control use test, tape test, repeated stimulation patch test, cumulative stimulation test, chamber scratch test, and improved soap chamber test. The experimenter can use different methods according to different experimental purposes. For example, complete and standardized test patches help diagnose and distinguish between allergic contact dermatitis and mild irritation. Furthermore, in addition to "irritating responses," key forearm-controlled trials are useful. Besides, in vitro tests such as collagen edema tests, elevation tests and tests have positive clinical significance in assessing chemical irritation.

4. Explore the protective effect of functional cosmetics on sensitive skin

4.1 Observation objects and groups

The observation objects were 114 patients who were diagnosed with facial allergic skin disease in the outpatient department of Renmin Hospital of Wuhan University from July 2008 to May 2009, all of whom were female [5].

Group A: purely topical functional cosmetics, 31 cases - group A: Apply functional products every morning and evening after cleansing. Using Avene Water Spray (150ml Avene Shu Spring Water Spray) to spray the surface and pat gently for absorption continuously. Then experimenters applied Avene Moisturizing Toner (200ml Avene Moisturizing Toner 200ml) with a cotton pad (Avene Fine Pressed Cotton Pad (50 pieces)) on the face, and applied Avene Living Spring Repair Moisturizing Cream (Avene Living Spring Repair Moisturizer Cream 40ml) spreading on the face;

Group B: pure external topical non-hormonal drugs (Shu Fulin Ointment (butylated hydroxybenzoic acid)), 37 cases, Shu Fulin ointment was applied topically after cleansing, once every morning and evening;

Group C: 46 cases of topical non-hormonal drugs combined with functional cosmetics, based on group A plus Shu Fulin ointment for external use, once a day in the morning and evening.

4.2 Statistical methods

Statistical methods: SPSS13.0 statistical software use for analysis. Counting data compare using the $X^2$ test. Measurement data were analyzed by using t-test. $P <0.05$ was considered a significant difference.

4.3 Observation indicators and judgment standards

4.3.1 Observation indicators

The clinician evaluated observation indicators before treatment, 24 hours, seven days, and 14 days after treatment. Actual index evaluation content: erythema, edema, dryness, desquamation. Subjective index evaluation content: itching, tightness, tingling, burning.

The index was evaluated by a semi-quantitative grading method: 0 points: none; 1 point: mild; 2 points: moderate; 3 points: severe Symptoms and signs improvement index (SSRI) = (points before treatment - points after treatment) / points before treatment × 100%. The scores of various indicators add to the disease score. Efficacy index = (pre-treatment disease point - post-treatment disease point) / pre-treatment disease point × 100%.
4.3.2 Evaluation criteria of curative effect:
Clinical cure: efficacy index > 90%;
Significant effect: The efficacy index is 60% ~ 90%;
Improvement: curative effect index 20% ~ 59%;
Ineffective: efficacy index < 20%. The curative effect is mainly a clinical cure, and the curative effect is significant.

4.4 Treatment results
Table 1 shows the improvement of the SSRI scores of the individual symptoms and signs in the functional cosmetic group and the non-hormonal group alone.

The results in Table 1 suggest that the dryness, tightness, and burning of the face in the pure topical functional cosmetic group were significantly better than those in the non-hormonal drug group alone (P < 0.05); the facial edema and erythema in the non-hormonal drug group alone were improved. The improvement of desquamation signs and tingling sensations was significantly better than that of the pure topical functional cosmetics group (P < 0.05); there was no significant statistical difference in the improvement of pruritus symptoms between the two groups.

Table 1. Symptoms and signs SSRI scores after treatment in 2 groups of patients

| Symptoms and signs | 14 days after treatment | 7 days after treatment | 24h after treatment |
|-------------------|------------------------|-----------------------|-------------------|
|                   | A                       | B                     | A                 | B                 |
| Erythema          | 9.67 ± 0.78            | 11.36 ± 0.69          | 28.11 ± 1.76      | 36.36 ± 2.22a     |
| Edema             | 9.09 ± 0.65            | 16.67 ± 0.87c         | 31.82 ± 2.46      | 45.83 ± 3.34b     |
| Dry               | 13.33 ± 1.42           | 6.13 ± 0.77*          | 36.67 ± 4.23      | 25.00 ± 2.95*     |
| Desquamation      | 6.67 ± 2.11            | 12.12 ± 2.43          | 33.33 ± 3.68      | 46.36 ± 4.55c     |
| Itching           | 10.53 ± 1.30           | 30.00 ± 3.22c         | 36.81 ± 2.97      | 37.50 ± 3.76      |
| Tightness         | 17.54 ± 2.49           | 9.38 ± 0.87c          | 67.69 ± 4.58      | 50.77 ± 3.58*     |
| Burning sensation | 11.11 ± 2.01           | 5.00 ± 1.13c          | 48.41 ± 4.62      | 37.50 ± 3.29*     |
| Tingling          | 16.67 ± 1.70           | 19.43 ± 1.77          | 16.67 ± 3.00      | 71.43 ± 4.79*     |

The use of functional cosmetics can significantly improve the therapeutic effect and speed of symptom relief of non-hormonal drugs alone and can be promoted and applied clinically, becoming a safe and reliable auxiliary treatment method. Moreover, most of its active ingredients are highly safe and have no toxic side effects. Not only can it alleviate the symptoms of the disease, but it can also effectively restore the skin's water and oil balance, improving the appearance of the skin, maintaining the health of the skin, and improving the quality of life. For healthy skin, it can reduce irritation, maintain natural skin barrier and balance, and resist external stimuli; for sensitive skin and problem skin, it can reduce skin sensitivity, play an auxiliary drug treatment, and reduce the use of drugs for disease outbreaks.

5. Toxicity analysis and recognition of chemicals in common skincare products
In the past, people's skincare mainly used natural raw materials (such as plant and rock ingredients). However, since the 20th century, the petroleum industry has greatly developed, and petrochemical raw materials used widely in our daily life, for example, most cosmetics and daily necessities are made from petrochemical raw materials.

Hazardous substances in cosmetics mainly come from chemical raw materials and excessively added banned restricted chemical substances. In fact, some manufacturers did not strictly implement the requirements of the Cosmetics Hygiene Regulations, resulting in some unqualified cosmetics entering the market. After using these unqualified products, the light ones will cause skin irritation, erythema, and edema, which will cause obvious damage to the skin and mucous membranes, and the serious ones will cause teratogenesis and cancer. China's "The Cosmetics Hygiene Regulations" stipulates lead content ≤40 mg/kg; mercury content ≤1 mg/kg; arsenic content ≤10 mg/kg.

The fact is that the ingredients in cosmetics are straightforward to get into the skin and blood. Once these substances enter the body, they can damage the endocrine and nervous system and may cause reproductive,
reproductive and developmental problems. The following are common chemicals in daily personal care and hygiene products, to understand their toxicity to human health.

5.1 Sodium lauryl sulfate (SLS) and sodium lauryl ether sulfate (SLES)

SLS and SLES are surfactants. Twelve sodium alkyl sulfate (SLS) is also a strong ionic sulfate surfactant. It has excellent detergency and is found in many foam cosmetics in shower and bathtub, using as a foaming cleaner in industrial cleaning products [6]. Sodium dodecyl sulfate is an anionic surfactant used in cosmetics with detergent properties. Therefore, it is very common in body wash and shampoo. However, it is produced by ethoxylation from sodium lauryl sulfate (SLS), which is a very polluting chemical transformation. Furthermore, sodium lauryl sulfate is less irritating than sodium laurel sulfate. Although the latter is more natural and recognized in the field of biotechnology, it is possible to soften and increase its foaming ability due to chemical conversion.

Sodium dodecyl sulfate, being harmful to the liver, can be absorbed by the skin maintaining in the body. However, its carcinogenic effect has not been confirmed. Overdose can cause difficulty breathing, and when swallowed, sodium lauryl sulfate can cause nausea, vomiting, diarrhea, and oesophageal irritation.

5.2 Phthalates

Phthalates are used widely in nail polishes, hair sprays, perfumes, lotions, deodorants, and humectants. For example, they are used as plasticizers (thinner and softeners). In addition, they have many other uses, such as retaining color, making nail polish brittle and preventing fixative from making hair too hard. However, people do not always find them on labels.

In 2002, three American Consumer Associations issued an alert: many cosmetics contain phthalates. Therefore, these potentially toxic substances have been banned from using in toys since 1999. However, these harmful health chemicals have been found in dozens of deodorants, shampoos, varnishes, and other moisturizers. When Phthalates are ingested during pregnancy, it is very harmful to the development of the male reproductive system.

5.3 Fragrances

Fragrances often add to the daily deodorants, perfumes, and colognes that people usually contact. Furthermore, it finds in almost all personal care products, including soaps, shower gels, shampoos, creams, lotions, and humectants. Therefore, fragrances are essential additives. This chemical is contained even in products labeled as odorless or fragrance-free.

One reason why it is more difficult to know exactly what the chemicals contain is that cosmetic manufacturers have so-called "rights" to protect their trade secrets, which gives them the right not to disclose the full list of ingredients, so consumers sometimes do not know what they are buying. Does the cosmetic contain fragrance? However, usually, these chemicals are not tested for toxicity individually or in combination.

Studies have shown that skin irritation, and runny nose is often associated with the use of fragrances. Perfume is one of the main allergens in the eyes of the chemist. Maybe not everyone knows how harmful fragrance is to skin. The essence itself is a mixture consisting of artificial or natural spices which are also a variety of chemical components, and some of them are mainly allergens and even carcinogenic.

5.4 Mineral oil

Mineral oil is a highly hydrophobic and occlusive fatty substance (waterproof) derived from hydrocarbons (coal or petroleum distillates). Because it prevents water from evaporating, it moisturizes by indirect action. It is widely used in a variety of skin creams and moisturizers, as well as in hair care products. However, mineral oils are often susceptible to contamination by polycyclic aromatic hydrocarbons (HPA). Long-term exposure to these substances’ links to cancer. What is more, HPA can also cause allergies and skin irritation. There is a standard for acceptable daily intake's mineral hydrogen carbon. For lip products, people should use no more than an acceptable daily intake (ADI). Eating natural mineral oil is toxic because it settles and accumulates in the user's stomach. People need to avoid using all kinds of balsam and lipstick whose ingredient is mineral oil. Therefore, breastfeeding women should avoid using all the cream on their chest when they are in oral contact with the baby.

5.5 Lead

Lead and its compounds are prohibited substances in cosmetic components. As impurities, the content of lead in cosmetics must not exceed 40 mg/kg (based on lead). However, except for hair dyes
containing lead acetate, the content must be less than 0.6% (Pb) in hair dye products. Lead can increase the whiteness of the skin in cosmetics, so the lead generally adds to whitening and whitening cosmetics.

Lead is toxic to all living things and its compounds and itself are harmful to human health through skin absorption. They mainly affect the hematopoietic system, nervous system, kidney, gastrointestinal tract, reproductive function, cardiovascular, immune and endocrine systems, especially fetal health. The main clinical manifestation is neurasthenia syndrome caused by central nervous system dysfunction. According to the Safe Cosmetics Campaign, lead can cause learning and behavior problems, reduce male fertility, cause hormonal imbalances, delay the onset of puberty in girls, and late development of testicles in boys. In fact, most lipsticks contain lead. It should note that there are no safe levels of lead in the blood, and even low concentrations can cause damage.

5.6 Formaldehyde

Formaldehyde, this dehydrogenated alcohol is an antibacterial preservative, and it is also the first group of substances classified by the International Cancer Research Agency as carcinogens for humans, especially the respiratory tract. For the respiratory tract, the residual effects of formaldehyde in the human body are acute and chronic exposures, which have irritating effects on the eyes and respiratory tract. Formaldehyde is also a source of nasopharyngeal carcinoma, a strong skin irritant, and allergic compound, often associated with adverse reactions (contact dermatitis or asthma).

Except for uses that are still very common in nail hardeners, it scarcely uses in cosmetics. Our daily formaldehyde content is shallow, so the formaldehyde-releasing agent content is different. If the content of formaldehyde in cosmetics is more significant than 0.05% in finished products, it must clearly state on the label.

6. Effects of skincare products on sensitive skin

6.1 Harm of cosmetics to sensitive skin

Cosmetics induce the formation of sensitive skin. With the widespread application of cosmetics, various problems have also appeared. For instance, people may face the risk of buying the low quality of cosmetics with excessive levels of toxic substances. After people use it, the main negative effects are cosmetic photodermatitis, irritative cosmetic dermatitis, cosmetic allergic contact dermatitis, cosmetic hormone dependent dermatitis, and cosmetic pigment. Abnormal dermatitis and hair damage caused by cosmetics. Various factors cause skin sensitivity, and their clinical manifestations are also different, most of which are subjective sensory abnormalities [7]. For example, the most common subjective feelings are itching, burning, tingling and dryness. Although different individuals have different manifestations and different degrees, most people will have corresponding skin discomfort or skin intolerance after using cosmetics.

People with sensitive skin will have more or less skin burning, itching, tingling, or tightness when using any cosmetics, which is intolerance to cosmetics. "Cosmetic intolerance" is considered as an extreme manifestation of sensitive skin. These patients show the corresponding discomfort after being slightly stimulated by cosmetics. At present, there are many reasons for cosmetic intolerance, mainly due to the combined effect of exogenous and endogenous factors. Exogenous factors can include subjective or objective stimuli, including potential allergic contact dermatitis and irritating dermatitis syndrome; endogenous factors include facial seborrheic dermatitis, rosacea, psoriasis disease, acne, neuropathy, and phobia of skin diseases.

For example, polyethylene glycol (PEG) is a suitable and stable oil dissolving encapsulant. Polymethylene glycol is used in detergents to dissolve oil and increase the viscosity of the product. Due to its significant effectiveness, polyethylene glycols are often used in corrosive oven cleaning sprays, but they find in many skincare products. However, scientific experiments have proven that some people are allergic to polyethylene glycols and that they have potential carcinogenic risk for degradation products of polyethylene glycol (PEG). Also, polyethylene glycol can cause the skin's natural moisturizing ingredients to peel off, leaving the immune system vulnerable.
6.2 Cosmetics improve the health condition of sensitive skin
With the change of social and economic level and the complexity of cosmetics types and ingredients, the possibility of sensitive skin appearing and being stimulated increases. Also, people's awareness of skin health and aesthetic standards has been improved. Therefore, people's attention to sensitive skin is gradually increasing. The cosmetics industry will put more and more important products on sensitive skin and develop anti-allergic ingredients of active substances for various reasons and manifestations of sensitive skin. According to the existing market research, except for some makeup brands, almost all makeup brands have launched a specific number and different types of products for sensitive skin. In these "Shumin" cosmetics, some anti-allergy and anti-stimulation plant extracts will be added with purslane, chamomile, tea polyphenol, artichoke oil which have anti-allergic and anti-irritant properties. Inflammation and anti-external stimulation can alleviate skin allergy, provide a natural protective barrier for skin, effectively repair damaged skin, stimulate cell biochemical synthesis and cell regeneration, and reconstruct skin immune system.

7. Conclusion
The exact meaning of sensitive skin has not yet agreed. Some scholars have defined sensitive skin as reduced tolerance to cosmetics and toiletries or environmental factors (compared to the average population). In other words, they cannot tolerate products or environmental factors that ordinary people can tolerate. The skin (especially the face) is highly sensitive, and the incidence of adverse reactions to cosmetics and toiletries is high. The symptoms can be visible irritations such as erythema and desquamation and also be subjective discomforts such as tingling, burning, itching, and tightness. Some scholars believe that this hyperresponsiveness of sensitive skin is a non-immune-mediated inflammation. The causes of sensitive skin are also related to various factors such as race, age, gender, and cosmetic irritation. The pathogenesis is complex, and there are great difficulties in treatment.

Cosmetics can induce the formation of sensitive skin. It is common to see the widespread use of cosmetics with harmful chemicals leads to the impairment of the epidermal barrier, resulting in sensitive skin [8]. Many people have to endure the negative effects of skin sensitivity. People ignore the corresponding symptoms or can't use the corresponding skincare products correctly, which aggravates the facial disease. However, hazardous substances in cosmetics mainly come from adding banned chemicals and excessive use of restricted chemical substances. This is because the merchant wants to let the user see the effect of the product in a short time. Furthermore, some manufacturers do not strictly implement the requirements of the "Cosmetic Hygiene Regulations", some unqualified cosmetics have flowed into the market. In order to strengthen the management and supervision of unqualified cosmetics, consumers should report when they buy unqualified products. People should use cosmetics produced by regular manufacturers to avoid being harmed by unqualified cosmetics.

All in all, skincare products have benefits and protective effects on people and also come with health risks. A correct evaluation of sensitive skin and products' chemical ingredients are essential to prevent and treat facial skin diseases.

Acknowledgement:
The assistance provided by Mr Liang was greatly appreciated.

References
[1] Z. Keyuan, research progress on the correlation between cosmetics and sensitive skin, Chinese Journal of Aesthetic Medicine. Vol.25. No.12. (2016)
[2] S. Watkins, J. Zippin. Allergic contact dermatitis and cosmetics[J]. 90(4):201-204. (2012)
[3] L. Misery, E. Myon, N. Martin, F. Verriere, T. Nocera, and C. Taieb, Sensitive skin in France: An epidemiological approach, Ann.Dermatol. Venereol, 132(5), 425–429. (2005)
[4] W. Xuemin, understanding sensitive skin and how to assess it, Journal of Clinical Dermatology Vol. 32 Number 11. (2003)
[5] S. Wang, H. Liang, Protective effect of functional cosmetics on sensitive skin, Chinese Journal of Aesthetic Medicine, Vol. 18. No 10. (2009)
[6] H. Loffler, R. Happle, Profile of irritant patch testing with detergents: Sodium lauryl sulfate, sodium laureth sulfate and alkyl polyglucoside. Contact Dermatitis, 48 (1), pp. 26-32. (2003)
[7] C. Lu, G. Cheng, L. Shen, et al. Designing a new model for cosmetic adverse reaction monitoring in China[J]. Contact Dermatitis, 73(1):29-35. (2015)
[8] A. Fauger, A. Lhoste, M. Chavagnac-Bonneville, et al. Effects of a new topical combination on sensitive skin[J]. 66(2):79-86. (2014)