Efficient Skin Protection Against Negative Environmental Influences by Breathable, Vegan Silk Polypeptides

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Skin protection is a growing concern for societies worldwide. Not only severely damaged and compromised skin requires special care products restoring impaired barrier functionality, but also healthy skin benefits from protection against environmental stress such as increasing pollution and manifold contact of individuals to irritants in everyday life. AMSilk presents an innovative active ingredient, forming a breathable protective film on skin. It is especially suited for products targeting sensitive, irritation-prone, stressed or diseased skin. Silkgel is an innovative hydrogel comprising biotechnologically produced functional silk polypeptides. In vitro as well as in vivo data show that an almost invisible film formed by the application of Silkgel represents an efficient barrier against potentially harmful small molecules, microorganisms and irritants, thereby supporting and enhancing the natural barrier function of skin. In parallel, skin appearance is improved (i.e., soft shine and smoothened surface). The functional silk polypeptides outperform standard ingredients such as ceramides or other skin barrier supporting film formers. The functional silk polypeptides are not animal derived and no animal derived products are used throughout the production process, rendering Silkgel a natural, vegan cosmetic ingredient.

Introduction

Skin’s manifold properties include a natural barrier function, metabolic activity and immune response as well as the ability to absorb vitamins, moisture, light, active ingredients among others. Active ingredients penetrate into the layers of the skin, supporting the regeneration of skin cells, stimulating collagen formation or refining skin complexion. Accordingly, skin can indeed be positively and efficiently supported by applying cosmetic products [2].

However, what about the irritants to which humans are exposed in everyday environment in an uncontrolled manner? Skin is not only negatively impacted by increased solar radiation but also by particulate matter, heavy metals or soot. (Fig. 1)

Negative Environmental Influences and their Effects on the Skin

For many years, UV-A and UV-B radiation has been known as a hazard to the skin that is clearly visible. Adverse effects such as sunburn or sun allergy can be prevented by using appropriate skin protection measures in order to avoid consequences ranging from premature skin aging to even skin cancer in extreme cases. But what about the continuously increasing air pollution, which especially occurs in the form of smog in large cities such as Delhi, Beijing and Shanghai? Every year about 3.3 million people worldwide succumb at an early age to diseases such as stroke, heart attack and respiratory illnesses – often brought in the context of suffering excessive air pollution. One of the main reasons is particulate matter caused by industry, agriculture and high traffic volume [3]. Therefore, it seems obvious that the skin can also be contaminated by pollutants, as it is the largest organ with a surface of about 1.5–2.0 m². It has been observed that larger particles which are contaminated with chemicals or metals adhere to the skin and may emit their pollutants into the skin. Finer particles with diameters of 2.5 microns or less are able to penetrate into the skin [4]. A recent study on women from Germany and China shows the relationship between traffic-based air pollution and pigment spots. An increase of 10 µg/m³ in nitrogen dioxide concentration was associated with a 25 % increase of dark skin spots. The most significant change was found at the cheeks of Asian women aged over 50 years, the part of the body that is most exposed to the environment [5]. Further effects of particle matters are the disturbance of the skin barrier, the damage...
to the skin tissue and the acceleration of skin aging. Skin which is exposed to severe air pollution, especially over long periods of time, may also show allergic reactions, inflammation, eczema, or redness [6]. There is also the possibility that polycyclic aromatic hydrocarbons (PAHs), which result from incomplete burning created by forest fires or diesel engines, penetrate through the hair follicles into lower layers of the skin, such as melanocytes, thereby adversely affecting the cell function [7]. Nicotine and chemical compounds in cigarette smoke generate reactive oxygen species (ROS) [8], which encourage skin disorders such as acne, eczema, psoriasis and even skin cancer risk. Due to oxidative stress, metabolism is disturbed, the epidermis cannot bind the moisture and cell renewal slows down. Thus, skin aging is accelerated and the skin gets more susceptible. Exposure at work should also be considered, since in Germany at least about 20,710 occupational skin diseases were confirmed in 2014 [9]. People can get in contact with chemicals such as detergents, alkalis, solvents and paints in their everyday working life. Without protective measures this equipment may cause skin diseases such as eczema and acid burns.

Protection for the Skin

As mentioned earlier, the skin acts as a natural shield. However, the capabilities of the skin are limited due to today’s prevailing environmental impacts. A great number of consumers already describe their skin as “very sensitive”; therefore, special attention to the quality of the cosmetic ingredients has to be paid.

Many cosmetic companies have been reacting to this for a long time and offer so-called “anti-pollution” products for protecting the skin. Especially the demand in Asia has been increasing for the last few years, because air pollution is a great burden in many metropolises there. But measurements indicate that air pollution also increases in European cities such as London or Paris, although the smog there is not at a hazardous state yet. Consumers continue to develop an awareness and are sensitized to this issue by companies and current incidents, such as the driving ban in Beijing in December last year due to air pollution. Consequently, people are looking for innovative, functional products, which not only protect the skin, but also nourish it. For environmental protection it is recommended to proceed in a similar way as when protecting against sunlight. Primarily, the skin should be proactively protected with creams or fluids to prevent the absorption of irritants. At the same time, many products contain conditioning agents, which have an antioxidant effect, moisturize or prevent premature aging of the skin. However, not only protection is important but also an intensive cleaning of the skin after exposure to pollution. Thus, cosmetic companies offer special cleaning products and also recommend mechanical cleaning brushes, which are intended to free the skin from particles more thoroughly.

Silkgel

The innovative functional silk polypeptides are produced via an established and standardized biotechnological approach leading to a consistent high-quality material. Bacteria derived from the human gastrointestinal tract (Escherichia coli) are an established industrial production platform. These hosts are cultivated in a special growth medium containing sugars, salts and nitrogen sources. During this process, the functional silk polypeptides are produced. The polypeptides are purified to homogeneity and are subsequently transformed into Silkgel (hydrogel). No animal derived sources are used in the whole manufacturing process rendering the proteins vegan. Unlike commonly used protein ingredients, the functional silk polypeptides are fully functional and not hydrolyzed. Thus, the proteins can unfold their full efficiency on top of the skin. Due to their rather large molecular weight (47.7 kDa), they do not penetrate into the skin. Silkgel is free of parabens, silicones and/or mineral oils and produced in accordance with the quality management system of ISO 9001. It is sustainable and biodegradable.

Silkgel is a hydrogel containing functional, non-hydrolyzed silk polypeptides and water. It is miscible with water as well as oil based formulations and spreads easily. Due to its shear-thinning properties, even Silkgel with high viscosity/consistency is sprayable and dispensable. When applied on skin, Silkgel generates a thin and transparent film. The silk proteins form a network of stable, three dimensional structures with small pores for air and water vapor exchange. Although any kind of surface can be coated with Silkgel in principle, it is especially suited for human skin.

Silkgel forms the protective and breathable film on the skin without the use of conventional chemicals or glues such as acrylates. The exclusively physical barrier becomes immediately functional after application. It supports the skin in its regeneration process. The silk film is long lasting, robust, not sticky and smooth to the touch. An enforced and even stronger barrier function is conceivable when using barrier supporting products containing parts of hydrolipidic layer accompanied with Silkgel.

Methods and Results

Protection against Atmospheric Pollution – in vivo Study

Atmospheric pollution is an increasing worldwide issue. There is a link between pollution and visible signs of aging that can be perceived by customers. Therefore, cosmetics combining protective ingredients to reduce exposure to pollution and irritants and anti-aging ingredients have a growing market. Silkgel is a protective ingredient that forms a breathable film on skin and hair surface. To determine to which extent atmospheric pollution such as carbon particles deposit and stick on the skin, samples of carbon particles (diameter 15 to 25 μm)
were applied on the skin of several test persons. Pictures taken before and after rinsing showed clearly that the adhesion of the carbon particles is significantly reduced when the silk film is applied on the skin (Fig. 2). Silk film serves as a protective barrier to carbon particles, particle matters and heavy metals.

**Protection against Irritants – in vivo Study**

Breaches of the skin barrier are common events in our daily lives due to the frequent use of detergents, surface active substances such as emulsifiers as well as various environmental factors. The exposure to surfactants erodes lipids and lipophilic compounds from the hydrophilic layer and natural moisturizing factors (NMF) from the stratum corneum. As a result, the stability of the corneal layer is decreased, the transepidermal water loss (TEWL) rises, the skin dries out, becoming itchy, and various kinds of molecules, including harmful substances, gain easier epidermal access.

The in vivo study to monitor the protective effect caused by the addition of Silkgel to cosmetic formulation was carried out at Dermatest GmbH, Münster. Two puffs (spray volume: 100 µL) of the test items (see Tab. 1) containing varying amounts of silk protein (silk concentrations: 0.25 % and 0.5 %) and a blank formulation without silk were applied on defined skin areas. After 10 minutes, 50 µl of 0.5 % sodium hydroxide and 1.0 % SDS were individually applied once a day for five consecutive days on the volar forearm of five healthy test persons for 60 minutes using 12 mm Finn chambers. To assess the irritation, the skin redness (chromatometry) as well as the transepidermal water loss (TEWL) were monitored before and after applying the irritant. Additionally, the ESCD score (European Society of Contact Dermatitis) was determined once a day before irritation. These three methods are excellent tools to draw conclusions regarding the skin condition.

The protective effect of Silkgel in cosmetic formulations was clearly demonstrated. Fig. 3 shows data for skin areas treated with 1.0 % SDS. The application of Silkgel (3 %) before irritation results in decreased redness (A-values), indicating that the silk film reduces the impact of the irritants on skin.

The next tool to investigate the impact of irritants on the barrier function of skin is the determination of the TEWL values. The unprotected skin areas treated with 0.5 % sodium hydroxide and 1.0 % SDS showed the highest TEWL values (25.49 g/hm² and 35.86 g/hm²). The skin barrier is

![SILK PROTECTED SKIN AREAS](image1)

**Application of carbon particles**

**After rinsing**

**UNPROTECTED SKIN AREAS**

**Application of carbon particles**

**After rinsing**

![Fig. 2 Carbon particles (diameter 15 to 25 µm) on unprotected and silk protected skin areas](image2)

![Chromatometry - 1.0 % SDS](image3)

**Skin area treated with 1.0 % SDS**

**unprotected**

**blank formulation**

**8.3 % Silkgel**

**16.5 % Silkgel**

![Fig. 3 Skin Protection by Silkgel (Chromatometry and Photography)](image4)

Tab. 1 Test formulations

<table>
<thead>
<tr>
<th>Test item 1</th>
<th>Test item 2</th>
<th>Test item 3</th>
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<tbody>
<tr>
<td>blank formulation</td>
<td>Blank formulation</td>
<td>Blank formulation</td>
</tr>
<tr>
<td>72.10 % Aqua</td>
<td>63.82 % Aqua</td>
<td>55.50 % Aqua</td>
</tr>
<tr>
<td>20.00 % Alcohol denat.</td>
<td>20.00 % Alcohol denat.</td>
<td>20.00 % Alcohol denat.</td>
</tr>
<tr>
<td>5.00 % Pentylene glycol</td>
<td>5.00 % Pentylene glycol</td>
<td>5.00 % Pentylene glycol</td>
</tr>
<tr>
<td>2.60 % Glycerol</td>
<td>2.60 % Glycerol</td>
<td>2.60 % Glycerol</td>
</tr>
<tr>
<td>0.20 % Hyaluronic acid</td>
<td>0.20 % Hyaluronic acid</td>
<td>0.20 % Hyaluronic acid</td>
</tr>
<tr>
<td>0.10 % Citric acid</td>
<td>0.08 % Citric acid</td>
<td>0.20 % Citric acid</td>
</tr>
<tr>
<td>8.3 % Silkgel (3 %)</td>
<td>16.5 % Silkgel (3 %)</td>
<td></td>
</tr>
<tr>
<td>5.00 % Pentylene glycol</td>
<td>5.00 % Pentylene glycol</td>
<td>5.00 % Pentylene glycol</td>
</tr>
<tr>
<td>2.60 % Glycerol</td>
<td>2.60 % Glycerol</td>
<td>2.60 % Glycerol</td>
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<tr>
<td>0.20 % Hyaluronic acid</td>
<td>0.20 % Hyaluronic acid</td>
<td>0.20 % Hyaluronic acid</td>
</tr>
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<td>0.20 % Citric acid</td>
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impaired due to the treatment. All test formulations had a positive impact on the skin condition. Especially when Silkgel is added to the formulation, the irritation is reduced dose-dependent. An amount of 8.3% resulted in a TEWL value of 18.14 g/hm², whereas an amount of 16.5% resulted in a TEWL value of 16.40 g/hm². The higher the amount of silk in the test formulations, the stronger is the protective effect (Fig. 4).

The ESCD score is an approved visual evaluation tool that determines the amount of acute skin irritation. The parameters erythema formation, dryness/surface, scaling, edemas and scissures are considered. The addition of silk protein to the test formulation has significant protective effects on all evaluation parameters (Fig. 5).

Conclusion

It was proven that the use of Silkgel in cosmetic formulations is a key factor in achieving protection of sensitive or stressed skin, during work safety and even as protective film forming ingredient in formulations targeting the treatment of diseased skin. Skin care products with Silkgel cover the skin like a secondary skin and can be washed off along with the pollutants in the evening. The breathability of the silk polypeptide film circumvents negative side effects such as heat accumulation or occlusion. The absence of tackiness, a soft feeling and a very good compatibility are only some of the great advantages of Silkgel. These characteristics of the vegan silk allow a huge range of applications for cosmetic care products, which counteract pollution.

References


