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(71) Applicant(s)
Novaliq GmbH

(72) Inventor(s)
LÖSCHER, Frank;GRILLENBERGER, Ralf;LEO, Chiara Silvana;BEIER, Markus

(74) Agent / Attorney
AJ PARK, GPO Box 2513, Sydney, NSW, 2001, AU

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(71) Applicant: **NOVALIQ GMBH** [DE/DE]; Im Neuenheimer Feld 515, 69120 Heidelberg (DE).

(72) Inventors: **LÖSCHER, Frank**; Burgweg 31, 69198 Schriesheim (DE). **GRILLENBERGER, Ralf**; Brehmstraße 12, 90443 Nürnberg (DE). **LEO, Chiara, Silvana**; Bahnhofstrasse 7, 69115 Heidelberg (DE). **BEIER, Markus**; Marc-Aurel-Weg 20, 69469 Weinheim (DE).

(74) Agent: **LEO, Chiara Silvana**; Im Neuenheimer Feld 515, 69120 Heidelberg (DE).

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(54) Title: TOPICAL SUNSCREEN FORMULATION

(57) Abstract: The present disclosure relates to topical sunscreen formulations comprising a semifluorinated alkane and a metal oxide selected from titanium dioxide, zinc oxide or mixtures thereof.



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TOPICAL SUNSCREEN FORMULATION

The present disclosure is in the field of topical sunscreen formulations.

Background of the invention

Human skin is sensitive to sunlight and artificial light in the wavelengths range between about 290 and 400 nm (uv light). Prolonged exposure to uv lights causes serious skin conditions from erythema, sunburns, reddening, blisterings to carcinomas.

Since increased incidence in skin cancer cases, such as squamous and basal cell carcinomas, has been reported worldwide, use of photoprotective agents has increased over the years. Photoprotective agents are commonly used either therapeutically or prophylactically.

A sunscreen, also known as sunblock, is a topical product that absorbs or reflects some of the sun's ultraviolet (UV) radiation and thus helps protect against sunburns.

A sunscreen typically comprises UV blockers or absorbers to reduce the negative impacts on the skin from the sun such as burning, wrinkles and cancer.

Ideal sun screening agents should be safe, chemically inert, non irritating, nontoxic, photostable, invisible, non-staining, non-greasy, and able to provide complete protection to the skin against damage from solar radiation. They should be formulated in a cosmetically acceptable form and ingredients should remain on the upper layers of the skin even after sweating and swimming. They should also effectively block both UVB and UVA rays.

Generally, sunscreens are available in the form of creams, lotion, gels, ointments, pastes, oils, butters, sticks, and sprays. Spray or gel-based sunscreens are preferred in oily skin and acne.

Common actives which are included in sunscreens are titanium dioxide, zinc oxide, avobenzene, benzophenone 8, octocrylene and oxybenzone, together with other agents like moisturising agents, humectants and emollients. Inorganic chemicals like titanium dioxide and zinc oxide absorb and scatter uv rays, unlike organic chemicals

which only absorb. When a sunscreen lotion is put on the skin, it forms a continuous film which provides protection from UV rays. Ideally, this film will spread easily and will be resistant to wash-off.

When formulating a sunscreen, various factors should be considered like the solubility and stability of some uv filters and, being cosmetic items, also the sensorial aspects. The ideal aim is the highest possible protection with the minimum possible amount of uv filters. Moreover, a high amount of sunscreen ingredients is often associated to a bad, like greasy or waxy, final perception of the skin. (Cosmetics 2017, 4, 15). Ease of application and cosmetic appeal are important in formulating sunscreen compositions. A sunscreen formulation should rub in easily, be non-sticky and invisible on the skin after application.

EP0433086 B1 describes sunscreen compositions comprising mixtures of titanium dioxide and zinc oxide. EP 3145473 B1 relates to sunscreen products comprising multilayer type encapsulations containing pigments in which excessive whiteness due to titanium dioxide and zinc oxide is visually masked upon skin application.

Summary of the invention

The objective of the present invention is to provide improved sunscreen formulations, which at the same time address and overcome the various issues and at least one of the limitations or disadvantages associated with prior art sunscreen formulations; and/or at least provide the public with a useful choice. In particular, the objective of the present invention is to provide a sunscreen formulation which is invisible after application on the skin, non-staining and non-greasy and which may be used to prevent skin disorders deriving from the exposure to the uv light.

The objective of the present invention is attained by the claims.

Without wishing to be bound by theory, the advantages of the sunscreen formulation of the present invention include a) quick penetration into the skin (stratum corneum), (b) complete penetration into the stratum corneum, leaving no whitish residues of the metal oxides on the surface of the skin, (c) therefore no discoloration or grease spots on

textiles/clothing, (d) leaving a silky feeling on the skin, (e) forming a water-repelling layer, (f) no clogging of the sebaceous glands.

In a first aspect, the present invention provides a sunscreen formulation, comprising a) a semifluorinated alkane b) a metal oxide selected from titanium dioxide, zinc oxide and mixtures thereof; and c) optionally a co-solvent and/or an oil component and/or an active ingredient.

5 In a second aspect, the invention provides the sunscreen formulation according to the first aspect of the invention, for use in a method of prevention of skin cell damage caused by UV-radiation.

0 In a third aspect, the invention provides the sunscreen formulation according to the first aspect of the invention, for use in a method of prevention of skin cancer.

5 In a fourth aspect, the invention provides a method of protecting and/or preventing the skin from consequences and/or damage caused by UV-radiation, comprising topically administering the sunscreen formulation according to the first aspect of the invention to the skin of a subject.

In a fifth aspect, the invention provides a kit comprising the sunscreen formulation according to the first aspect of the invention and a container for holding the sunscreen formulation.

Also described herein is a sunscreen formulation comprising a semifluorinated alkane, a metal oxide selected from titanium dioxide, zinc oxide and any combination thereof, and optionally a co-solvent and/or an oil component and/or an active ingredient.

Also described herein is the use of a sunscreen formulation according to the first aspect of the invention for protecting the skin from sunburn.

Also described herein is a sunscreen formulation according to the first aspect of the invention for use as a medicine.

In the description in this specification reference may be made to subject matter that is not within the scope of the claims of the current application. That subject matter should be readily identifiable to a person skilled in the art and may assist in putting into practice the invention as defined in the claims of this application.

Detailed description of the invention

In a first aspect the present invention provides a sunscreen formulation comprising a semifluorinated alkane and a metal oxide selected from titanium dioxide, zinc oxide and mixtures thereof.

The term "semifluorinated alkane", also referred to as "SFA" throughout this document, as used herein refers to a linear or branched compound composed of at least one perfluorinated segment (F-segment) and at least one non-fluorinated hydrocarbon segment (H-segment). Preferably, the semifluorinated alkane is a linear or branched compound composed of one perfluorinated segment (F-segment) and one non-fluorinated hydrocarbon segment (H-segment). Preferably, said semifluorinated alkane is a compound that exists in a liquid state within the temperature range of 4° to 40°C. In one embodiment, the perfluorinated segment and/or the hydrocarbon segment of the said SFA optionally comprises or consists of a cyclic hydrocarbon segment, or optionally said SFA comprises an unsaturated moiety within the hydrocarbon segment.

It is preferred that the F- and the H-segment of the linear or branched semifluorinated alkane comprise, independently from one another, 2 to 10 carbon atoms.

According to a preferred embodiment of the present invention, the semifluorinated alkane is a linear compound of the formula (I) $CF_3(CF_2)_n(CH_2)_mCH_3$, wherein n and m are integers independently selected from each other from the range of 2 to 10.

According to another nomenclature, the linear semifluorinated alkane may be referred to as F_nH_m , wherein F means the perfluorinated hydrocarbon segment, H means the non-fluorinated hydrocarbon segment and n, m is the number of carbon atoms of the respective segment. For example, F_4H_5 is used for 1-perfluorobutyl-pentane. In a preferred embodiment of the present invention, the semifluorinated alkane is a semifluorinated alkane of formula (I) $CF_3(CF_2)_n(CH_2)_mCH_3$ wherein n is selected from

3 to 5 and m is selected from 4 to 9. More preferred is a semifluorinated alkane selected from F4H5, F4H6, F4H8, F4H10, F6H8, F6H10 and combinations thereof. Most preferred is a semifluorinated alkane selected from F4H8, F6H8 and F6H10. Even most preferred is F6H8, 1-perfluorohexyloctane.

5 Preferably the formulation of the present invention comprises a semifluorinated alkane at a concentration of from 45 to 95 percent by weight, more preferably from 50 to 95 percent by weight, even more preferably from 70 to 95 percent by weight based on the total weight of the formulation. Most preferably, the semifluorinated alkane is present at a concentration of from 80 to 95 percent by weight based on the total weight of the
0 formulation.

In a preferred embodiment, the semifluorinated alkane is present at a concentration of at least 45 percent by weight, preferably at least 50 percent by weight, more preferably at least 70 percent by weight, most preferably at least 80 percent by weight based on
5 the total weight of the formulation.

The sunscreen formulation of the present invention comprises a metal oxide selected from titanium dioxide, zinc oxide and mixtures thereof. The metal oxide may be present at a concentration of from 1 to 20 percent by weight with respect to the total weight of
0 the formulation. In a preferred embodiment, the sunscreen formulation of the present invention comprises titanium dioxide or zinc oxide or mixtures thereof at a concentration of from 1 to 20 percent by weight, preferably of from 1 to 10 percent by weight based on the total weight of the formulation.

25 In a preferred embodiment, the metal oxide is TiO₂. In a more preferred embodiment, the metal oxide is TiO₂ at a concentration of from 1 to 10 percent by weight, based on the total weight of the formulation.

In another preferred embodiment, the metal oxide is ZnO. Preferably, ZnO is present at
30 a concentration of from 1 to 20 percent by weight based on the total weight of the formulation.

5 Preferably the metal oxide has a mean particle diameter in the range of 1 to 100 nm, more preferably in the range of from 1 to 50 nm. In a preferred embodiment, the metal oxide is titanium dioxide having a mean particle diameter of from 1 to 50 nm. In a more preferred embodiment, the metal oxide is titanium dioxide having a mean particle diameter of from 1 to 50 nm at a concentration of from 1 to 10 percent by weight based on the total weight of the formulation.

0 In the present invention a solid thickening agent may be comprised in the sunscreen formulation. Solid thickeners which may be employed in the present invention comprise plant waxes, animal waxes, petroleum derived waxes, triglycerides, C₁₂₋₂₄ fatty acids, fatty alcohols, fatty alcohols derivatives and combinations thereof. Non limiting examples of waxes are bees wax, lanolin wax (wool wax), lanolin wax derivatives, carnauba wax, candelilla wax, castor wax, rice bran wax, spermaceti wax, bran wax, montan wax, kapok wax, bay berry wax, shellac wax, sugar cane wax, paraffin wax, 5 ceresin wax.

0 In a preferred embodiment, the solid thickening agent is selected from plant waxes, animal waxes, petroleum derived waxes, triglycerides, cetyl alcohol, tetradecanol and combinations thereof. More preferably, the solid thickening agent is selected from beeswax, paraffin wax, cetyl alcohol and combinations thereof.

25 The solid thickening agent may be comprised at a concentration of from 1 to 20 percent by weight, preferably of from 1 to 10 percent by weight based on the total weight of the formulation.

Preferably, the formulation of the present invention does not comprise any preservative.

30 Water can also be present in the formulation of the present invention, however preferably in small or trace amounts of up to 1,0 percent by weight or even up to 0,1 percent by weight based on the total weight of the formulation. In a preferred embodiment, the formulation of the present invention is essentially free of water, whereas the residual water may be attributed to the potential water content of the

chosen active ingredient. The term 'essentially' as used herein means if present then in trace or residual amounts such as to confer no technical advantage or relevance in respect of the object of the invention. In a preferred embodiment the sunscreen formulation is water free.

In a more preferred embodiment, the sunscreen formulation is preservative and water free. Preferably, the sunscreen formulation of the present invention is an ointment, more preferably a water free ointment.

Optionally, the sunscreen formulation of the present invention comprises a cosolvent and/or an oil component and/or an active ingredient.

The formulation of the present invention may further comprise an active ingredient. Preferably, the active ingredient is one selected from panthenol, thymol, tea tree oil, retinol palmitate, tocopherol. More preferably the active ingredient is selected from D-panthenol, retinol palmitate, tocopherol and esters thereof.

The active ingredient may be comprised at a concentration of up to 10 percent by weight, preferably of up to 5 percent by weight, with respect to the total weight of the formulation. In a preferred embodiment, the active ingredient is present at a concentration of from 0.05 to 10 percent by weight, preferably of from 0.05 to 5 percent by weight with respect to the total weight of the formulation.

The sunscreen formulation of the present invention may comprise a cosolvent. In a preferred embodiment, the cosolvent is present at a concentration of up to 10 percent by weight, more preferably up to 5 percent by weight based on the total weight of the formulation. More preferably the cosolvent is present at a concentration of from 0.5 to 10 percent by weight, most preferably of from 0.5 to 5 percent by weight based on the total weight of the formulation.

Examples of cosolvents which may be included in the formulation of the present invention are isopropanol, ethanol, liquid medium chain triglycerides, N-methyl-2-pyrrolidone, diethylene glycol monomethylether, diethylene glycol monoethylether,

ethyl acetate, ethyl oleate, octyldodecanol, diethyl sebacate. Preferably, the cosolvent is selected from isopropanol, ethanol, liquid medium chain triglycerides, diethylene glycol monoethylether, diethyl sebacate.

5 The sunscreen formulation of the present invention may comprise an oily material. Examples of oily materials are squalane, squalene, essential oils, liquid triglycerides, silicone oils like cyclomethicone and dimethicone, mineral oils, emollient vegetable oils such as olive, coconut, jojoba, sesame, avocado, sunflower, safflower, borage, corn, and sea buckthorn oil. In a preferred embodiment, the sunscreen formulation of the present invention comprises an oily material selected from squalane, squalene, silicone oils, mineral oils, essential oils, liquid triglycerides, vegetable oils.

An oily material may be present at a concentration of from 1 to 45 percent by weight, preferably of from 1 to 20 percent by weight, more preferably of from 1 to 10 percent
5 by weight based on the total weight of the formulation.

In a preferred embodiment, the sunscreen formulation of the present invention comprises squalane. Preferably squalane is present at a concentration of from 1 to 45 percent by weight, more preferably from 1 to 20 percent by weight, most preferably
0 from 1 to 10 percent by weight based on the total weight of the formulation.

Emollients like isopropyl myristate and isopropyl palmitate can be included in the formulation of the present invention.

25 All the embodiments and preferred embodiments relating to the formulation of the first aspect of the invention as described above apply also to any of the following aspects of the present invention.

In a second aspect the present invention provides the sunscreen formulation according to the first aspect of the invention, for use in a method of prevention of skin cell damage caused by UV-radiation.

Also described is the use of the sunscreen formulation according to the first aspect of the invention for protecting the skin from sunburns.

In a third aspect, the present invention provides the sunscreen formulation according to the first aspect of the invention, for use in a method of prevention of skin cancer.

Also described is the use of the sunscreen formulation according to the first aspect of the invention for use as a medicine. In particular, the formulation according to the first aspect of the present invention may be used in a method of preventing skin cancer, such as melanoma, basal cell carcinoma and squamous cells carcinoma.

In a fourth aspect the disclosure provides a method of protecting and/or preventing the skin from consequences and/or damage caused by UV-radiation, comprising topically administering the sunscreen formulation according to the first aspect of the invention to the skin of a subject.

In a fifth aspect, the present disclosure provides a kit comprising the sunscreen formulation according to the first aspect of the invention and a container for holding the formulation. The container can be for example a jar, a tube, a bottle, a dispenser or other types of containers suitable for holding the formulation. The containers can have for example a pump and/or a squeeze mechanism.

The kit may include a package comprising the container in which the formulation of the first aspect of the present invention is placed. In the package, instructions for use can be included.

Also described is the formulation according to the first aspect of the invention for use in a method of preventing sunburns and skin cell damage caused by uv radiations.

Examples of skin cell damages are photoaging, actinic or solar keratoses. Sunburn, also called erythema, is one of the signs of UV exposure and skin damage. Sunburn is a form of short-term skin damage, characterised by redness and peeling after a few days.

In summary the present invention and disclosure comprises the following preferred items:

1. A sunscreen formulation, comprising:
a semifluorinated alkane,
1-6 wt% of a metal oxide selected from titanium dioxide, zinc oxide and mixtures thereof,
a solid thickening agent and
optionally a co-solvent and/or oil component and/or active ingredient.
2. The sunscreen formulation of any preceding items, wherein the semifluorinated alkane is of formula $F(CF_2)_n(CH_2)_mH$, wherein n is an integer from 4-6 and m is an integer from 5-10.
3. The sunscreen formulation of any preceding items, wherein the semifluorinated alkane is selected from 1-perfluorohexyl-octane (F6H8), 1-perfluorobutyl-pentane (F4H5), 1-perfluorohexyl-decane (F6H10), 1-perfluorobutyl-octane (F4H8), 1-perfluorobutyl-decane (F4H10) and combinations thereof.
4. The sunscreen formulation of any preceding items, wherein the semifluorinated alkane is 1-perfluorohexyl-octane (F6H8).
5. The sunscreen formulation of any preceding items, wherein the formulation comprises 50-95 wt% of semifluorinated alkane.
6. The sunscreen formulation of any preceding items, wherein the formulation comprises 80-84 wt% of a semifluorinated alkane, about 4-6 wt% of the metal oxide, 3-8 wt% of the solid thickening agent, preferably 80-84 wt% of 1-perfluorohexyloctane, 4-6 wt% of the metal oxide and 3-8 wt% of the solid thickening agent, based on the total weight of the formulation.
7. The sunscreen formulation of any preceding items, wherein the formulation comprises 80-84 wt% of a semifluorinated alkane, about 4-6 wt% of titanium dioxide, 3-8 wt% of the solid thickening agent.
8. The sunscreen formulation of any preceding items, wherein the metal oxide particles have a mean particle diameter of between 1-100 nm.
9. The sunscreen formulation of any preceding items, wherein the solid thickening agent is a natural or synthetic thickening agent.

10. The sunscreen formulation of any preceding items, wherein the formulation comprises at least 1 wt%, preferably at least 3 wt%, more preferably at least 5 wt% of the solid thickening agent based on the total weight of the formulation.
11. The sunscreen formulation of any preceding items, wherein the formulation comprises at most 40 wt%, preferably at most 30 wt%, more preferably at most 20 wt%, most preferably at most 10 wt% of the solid thickening agent based on the total weight of the formulation.
12. The sunscreen formulation of any preceding items, wherein the natural or synthetic thickening agent is selected from plant waxes, animal waxes, petroleum derived waxes, triglycerides, cetyl alcohol, tetradecanol or combinations thereof.
13. The sunscreen formulation of any preceding items, wherein the thickening agent is a wax selected from the group consisting of bees wax, lanolin (wool wax), carnauba wax, candelilla wax, castor wax, rice bran wax (rice wax), spermaceti wax, jojoba oil, bran wax, montan wax, kapok wax, bay berry wax, shellac wax, sugar cane wax, paraffin wax, ceresin wax.
14. The sunscreen formulation of any preceding items, wherein the total amount of the co-solvent, oil component and the active ingredient in the formulation is up to about 45 wt%, preferably up to about 20 wt%, more preferably up to about 10 wt%.
15. The sunscreen formulation of any preceding items, in form of an ointment.
16. The sunscreen formulation of any preceding items, wherein the sunscreen formulation has a sun protection factor of at least 6.
17. The sunscreen formulation of any preceding items, wherein the formulation is water-free.
18. The sunscreen formulation of any preceding items, wherein the formulation is preservative-free.
19. The sunscreen formulation of any of the preceding items, comprising an active ingredient selected from panthenol, thymol, tea tree oil, retinol palmitate, tocopherol.
20. Use of a sunscreen formulation according to any of the items 1 to 19 for protecting the skin from sunburn.
21. The composition according to any of the items 1 to 19, for use as a medicine.

22. The composition according to any of the items 1 to 19, for use in the prevention of skin cell damage caused by UV-radiation.
23. The composition according to any of the items 1 to 19, for use in the prevention of skin cancer.
24. A method of protecting and/or preventing the skin from consequences and/or damage caused by UV-radiation, comprising topically administering the sunscreen formulation as defined in items 1 to 19 to the skin of a subject.
25. The method of item 24, wherein the method is effective in protecting the skin from sunburn.
26. A method of item 24, wherein the method is effective in preventing skin cell damage caused by UV-radiation.
27. The method of items 24 to 26, wherein the method is effective in preventing the development of skin cancer.
28. A kit comprising the sunscreen formulation as defined in any of the items 1 to 19. and a container for holding the sunscreen formulation.
29. A process for the production of a sunscreen formulation according to any of the preceding items.
30. The process of item 29, comprising the step of
 - a) mixing all the ingredients
 - b) heating up till about 80°C
 - c) cooling down at room temperature

EXAMPLES

Example 1: Sunscreen formulations

The ingredients of each formulation were weighed in a suitable container.

The ingredients used in the following formulations are: Paraffin wax (Sigma Aldrich, CAS 8002-74-2), Squalane (Sigma Aldrich, CAS 111-01-3), F6H8 (Novaliq), Cetyl alcohol (Sigma Aldrich, CAS 36653-82-4, 99%), TiO₂ (Sigma Aldrich; primary particle size 21 nm; CAS 13463-67-7), beeswax (Acros Organics; CAS 8012-89-3), ZnO (Aliacura; 100-200 nm; CAS 1314-13-2).

Table 1

SC-1	*wt%
Beeswax	2,2
Paraffin wax	2,2
Cetyl alcohol	2,2
Squalane	6,7
TiO ₂	5,2
F6H8	81,5

*wt% indicates the amount of each ingredient in percent by weight based on the total weight of the composition.

After all ingredients listed in Table 1 are weighed, the container is closed and heated to approx. 80 °C using a waterbath. After visual confirmation that all ingredients, except titanium dioxide, are melted and form a homogeneous mixture, the mixture is taken out of the water bath and allowed to cool down to room temperature. After cooling down, a white semisolid mixture is obtained. Gentle stirring of this mixture leads to an easy applicable formulation.

Following the instructions above, the following sunscreen formulations (SC2-SC5) were prepared:

SC-2	wt%
Beeswax	2
Paraffin wax	1,5
Cetyl alcohol	1,5
Squalane	7
TiO ₂	5
F6H8	83

SC-3	wt%
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Beeswax	3
ZnO	5
F6H8	92

SC-4	wt%
Beeswax	3,5
TiO ₂	5
F6H8	91,5

SC-5	wt%
Beeswax	2,5
Paraffin wax	2,5
Squalane	45
TiO ₂	5
F6H8	45

Example 2: Administration

The formulations of Example 1 (SC-1 to SC-5) present as highly pleasant semi-solid formulations. When administered to the skin of the forearm, a silky feeling was recognized, with the formulations absorbing very quickly into the skin. While shortly after administration still a white color was observable, within 30-60 seconds this colour completely disappeared after gentle massaging, demonstrating that the formulations including the metal oxides readily penetrated into the stratum corneum, leaving not even traces of the coloring metal oxides on the surface of the skin. Further, after being completely absorbed into the skin, the sunscreen formulations did not leave any

unpleasant greasy feeling behind. Contact of the sunscreen skin with textiles/clothing did not lead to discoloration or greasy spots.

The term “comprising” as used in this specification and claims means “consisting at least in part of”. When interpreting statements in this specification and claims which include the term “comprising”, other features besides the features prefaced by this term in each statement can also be present. Related terms such as “comprise” and “comprises” are to be interpreted in similar manner.

In this specification where reference has been made to patent specifications, other external documents, or other sources of information, this is generally for the purpose of providing a context for discussing the features of the invention. Unless specifically stated otherwise, reference to such external documents is not to be construed as an admission that such documents, or such sources of information, in any jurisdiction, are prior art, or form part of the common general knowledge in the art.

Claims

1. A sunscreen formulation, comprising
 - a) a semifluorinated alkane
 - b) a metal oxide selected from titanium dioxide, zinc oxide and mixtures thereof; and
 - c) optionally a co-solvent and/or an oil component and/or an active ingredient.
2. The sunscreen formulation of claim 1, wherein the formulation comprises a solid thickening agent.
3. The sunscreen formulation of claim 1 or 2, wherein the metal oxide is present at a concentration of from 1 to 6 percent by weight based on the total weight of the formulation.
4. The sunscreen formulation of claim 1 or 2, wherein the metal oxide is present at a concentration of from 1 to 20 percent, preferably of from 1 to 10 percent by weight based on the total weight of the formulation.
5. The sunscreen formulation of any one of claims 1 to 4, wherein the semifluorinated alkane is of formula $F(CF_2)_n(CH_2)_mH$, wherein n and m are integers independently selected from each other from 2 to 10.
6. The sunscreen formulation of any one of claims 1 to 5, wherein the semifluorinated alkane is of formula $F(CF_2)_n(CH_2)_mH$, wherein n is an integer selected from 4 to 6 and m is an integer selected from 5 to 10.
7. The sunscreen formulation of any one of claims 1 to 6, wherein the semifluorinated alkane is selected from the group consisting of 1-perfluorohexyl-octane (F₆H₈), 1-perfluorobutyl-pentane (F₄H₅), 1-perfluorobutyl-hexane (F₄H₆), 1-perfluorohexyl-decane (F₆H₁₀), 1-perfluorobutyl-octane (F₄H₈), 1-perfluorobutyl-decane (F₄H₁₀) and combinations thereof.

- 5 8. The sunscreen formulation of any one of claims 1 to 7, wherein the formulation comprises at least 45%, preferably 50-95 wt% of semifluorinated alkane, based on the total weight of the formulation.
- 5 9. The sunscreen formulation of any one of claims 1 to 8, wherein the metal oxide particles have a mean particle diameter of between 1-100 nm or of between 1-50 nm.
- 0 10. The sunscreen formulation of any one of claims 1 to 9, wherein the formulation comprises 1 to 40 wt% of the solid thickening agent, based on the total weight of the formulation.
- 5 11. The sunscreen formulation of any one of claims 1 to 10, wherein the thickening agent is a natural or synthetic thickening agent selected from plant waxes, animal waxes, petroleum derived waxes, triglycerides, C12-24 fatty acids, fatty alcohols, fatty alcohols derivatives, cetyl alcohol, tetradecanol or combinations thereof.
- 0 12. The sunscreen formulation of claim 11, wherein the wax is selected from the group consisting of bees wax, lanolin, wool wax, carnauba wax, candelilla wax, castor wax, rice bran wax, rice wax, spermaceti wax, jojoba oil, bran wax, montan wax, kapok wax, bay berry wax, shellac wax, sugar cane wax, paraffin wax, and ceresin wax.
- 25 13. The sunscreen formulation of any one of claims 1 to 12, wherein the oil component is selected from squalane, squalene, essential oils, liquid triglycerides, silicone oils, mineral oils, emollient vegetable oils.
- 30 14. The sunscreen formulation of claim 13, wherein the silicone oil is selected from cyclomethicone and dimethicone, or the emollient vegetable oils is selected from olive, coconut, jojoba, sesame, avocado, sunflower, safflower, borage, corn, and sea buckthorn oil.

15. The sunscreen formulation of any one of claims 1 to 14, wherein the oil component is present at a concentration of from 1 to 45 percent by weight, preferably from 1 to 10 percent by weight, or from 1 to 20 percent by weight, based on the total weight of the formulation.
16. The sunscreen formulation of any one of claims 1 to 15, wherein the oil component is squalane, being present at a concentration of from 1 to 45 percent by weight, or from 1 to 20 percent, or from 1 to 10 percent by weight, based on the total weight of the formulation.
17. The sunscreen formulation of any one of claims 1 to 15, wherein the cosolvent is present at a concentration of up to 10 percent by weight, preferably the cosolvent is present at a concentration of from 0.5 to 10 percent by weight, based on the total weight of the formulation.
18. The sunscreen formulation of any one of claims 1 to 17, in form of an ointment.
19. The sunscreen formulation of any one of claims 1 to 18, wherein the formulation is water-free and /or preservative-free.
20. The sunscreen formulation of any one of claims 1 to 19, comprising an active ingredient selected from the group consisting of: panthenol, thymol, tea tree oil, retinol palmitate, and tocopherol.
21. The sunscreen formulation of any one of claims 1 to 20, wherein the active ingredient is present at a concentration of up to 10 percent by weight, preferably the cosolvent is present at a concentration of from 0.05 to 10 percent by weight, based on the total weight of the formulation.
22. The sunscreen formulation according to any one of the claims 1 to 21, for use in a method of prevention of skin cell damage caused by UV-radiation.

- 23. The sunscreen formulation according to any one of the claims 1 to 21, for use in a method of prevention of skin cancer.
- 24. Use of a sunscreen formulation according to any of the claims 1 to 21 for protecting the skin from sunburn.
- 25. A kit comprising the sunscreen formulation according to any one of claims 1 to 21 and a container for holding the sunscreen formulation.
- 26. A method of protecting and/or preventing the skin from consequences and/or damage caused by UV-radiation, comprising topically administering the sunscreen formulation of any one of claims 1 to 21 to the skin of a subject.

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