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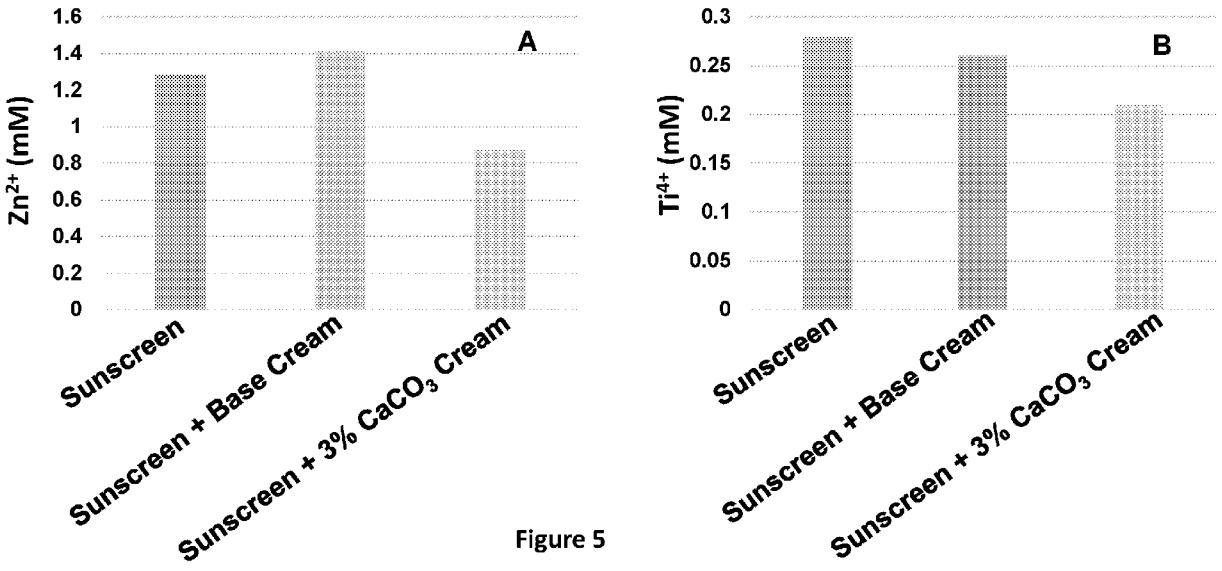

Figure 5

(57) Abstract: The present invention relates to a sunscreen composition for application to a user's skin. The sunscreen composition is provided with a mineral including zinc oxide, titanium dioxide, or a combination of both. The sunscreen composition also includes high buffering-capacity agent configured to react with an external acidic source coming in contact with the sunscreen composition and to inhibit release of zinc ions from the zinc oxide and/or to inhibit release of titanium ions from the titanium dioxide.

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COMPOSITION FOR SUNSCREEN COSMETICS

CROSS-REFERENCE TO RELATED APPLICATION

[00001] This application claims priority to U.S. Provisional Application No. 63/029,039 filed May 22, 2020, the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[00002] The present invention relates to the fields of sunscreen cosmetics, methods for making and using sunscreen cosmetics, and methods for preventing toxic effects of sunscreen cosmetics containing minerals.

BACKGROUND OF THE INVENTION

[00003] Many different sunscreen cosmetic compositions have been developed in the past. The sunscreen cosmetic compositions described herein inhibit toxic effects of sunscreen cosmetics containing minerals.

SUMMARY OF THE INVENTION

[00004] In one embodiment, a high buffering-capacity ("HBC") agent is incorporated into a sunscreen cosmetic having an oxide-based mineral. In one embodiment, the sunscreen cosmetic includes a transition metal oxide-based mineral. In one embodiment, the sunscreen cosmetic includes zinc oxides (ZnO) and/or titanium dioxides (TiO_2). In one embodiment, the sunscreen cosmetic includes a composition for a cream, a lotion, a spray, a gel, a foam, a stick, or other topical composition that can be absorbed into skin. In one embodiment, the HBC agent includes at least one of pearl powder and an analog thereof (e.g., one with high alkaline cation from the second column of the periodic table (e.g., alkaline earth metals) but weak acid (e.g., pKa range from 3 to 6)). In another embodiment, the HBC agent includes at least one of pearl powder, calcium carbonate, calcium citrate, calcium phosphate, calcium silicate, calcium molybdate, calcium tungstate, magnesium carbonate, magnesium phosphate, magnesium silicate, magnesium selenate, barium carbonate, barium phosphate, barium silicate, barium oxalate, barium molybdate, barium manganate, barium selenate, beryllium carbonate, beryllium phosphate, beryllium silicate, strontium carbonate, strontium phosphate, strontium silicate, strontium molybdate, strontium tungstate, strontium selenate, and a combination thereof.

[00005] In one embodiment, a sunscreen cosmetic composition includes oxide-based minerals and a high buffering-capacity ("HBC") agent. In one embodiment, the sunscreen cosmetic composition includes transition oxide-based minerals and the HBC agent. In one embodiment, the sunscreen cosmetic composition includes zinc oxides and/or titanium dioxides and the HBC agent. In one embodiment, the HBC agent includes at least one of pearl powder and an analog thereof (e.g., one with high alkaline cation from the second column of the periodic table (e.g., alkaline earth metals) but weak acid (e.g., pKa range from 3 to 6)). In another embodiment, the high buffering capacity agent includes at least one of pearl powder, calcium carbonate, calcium citrate, calcium phosphate, calcium silicate, calcium molybdate, calcium tungstate, magnesium carbonate, magnesium phosphate, magnesium silicate, magnesium selenate, barium carbonate, barium phosphate, barium silicate, barium oxalate, barium molybdate, barium manganate, barium selenate, beryllium carbonate, beryllium phosphate, beryllium silicate, strontium carbonate, strontium phosphate, strontium silicate, strontium molybdate, strontium tungstate, strontium selenate, and a combination thereof.

[00006] The inventor herein has discovered, surprisingly and unexpectedly, that under an acidic condition, zinc oxides and titanium dioxide in cosmetics can be solubilized and release "free" zinc ions and titanium ions, which can be absorbed in the skin and can have toxic effects (e.g., oxidative or carcinogenic). In one embodiment, when an external acidic material is introduced to the sunscreen cosmetic applied to skin, the HBC agent is configured to maintain the pH of the sunscreen cosmetic at or near neutral (e.g., pH 7), thereby inhibiting solubilization of the zinc oxides and titanium dioxides contained in the sunscreen cosmetic and inhibiting release of "free" zinc and titanium ions therefrom. In one embodiment, the external acidic material can be an endogenous source, such as the skin and/or sweat excreted therefrom, and/or an exogenous source, such acidic rain. The HBC agent therefore keeps the sunscreen cosmetic safe for use by a user.

BRIEF DESCRIPTION OF THE DRAWINGS

[00007] For a better understanding of the present invention, reference is made to the following detailed description of various exemplary embodiments considered in conjunction with the accompanying drawings, in which:

[00008] Figure 1 shows the results of an example illustrating the release of water soluble zinc ions and titanium ions in commercially available mineral sunscreens;

[00009] Figure 2 shows the results of an example illustrating the effect of acidic conditions on the release of zinc ions and titanium ions in commercially available mineral sunscreens;

[00010] Figure 3 shows the results of an example illustrating the effects of varying amounts of calcite on the solubilization of zinc oxide in acidic conditions;

[00011] Figures 4A and 4B show the results of an example illustrating the effects of varying amounts of calcite on the inhibition of zinc oxide solubilization by consuming acid first and then release calcium ions in low concentration acidic conditions; and

[00012] Figure 5 shows the results of an example illustrating the effects of varying amounts of calcite on the buffering capacity of mineral sunscreens.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[00013] Embodiments are now discussed in more detail referring to the drawings that accompany the present application. It is to be understood that the disclosed embodiments are merely illustrative of the disclosure that can be embodied in various forms. In addition, each of the examples given in connection with the various embodiments is intended to be illustrative, and not restrictive. Further, the figures are not necessarily to scale, and some features may be exaggerated to show details of particular components (and any size, material and similar details shown in the figures are intended to be illustrative and not restrictive). Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the disclosed embodiments.

[00014] Subject matter will now be described more fully hereinafter with reference to the accompanying drawings, which form a part hereof, and which show, by way of illustration, specific example embodiments. Subject matter may, however, be embodied in a variety of different forms and, therefore, covered or claimed subject matter is intended to be construed as not being limited to any example embodiments set forth herein; exemplary embodiments are provided merely to be illustrative. Among other things, for example, subject matter may be embodied as methods, devices, components, or systems. The following detailed description is, therefore, not intended to be taken in a limiting sense.

[00015] Throughout the specification and/or claims, terms may have nuanced meanings suggested or implied in context beyond an explicitly stated meaning. Likewise, the phrase “in one embodiment” as used herein does not necessarily refer to the same embodiment and the phrases “in another embodiment” and “other embodiments” as used herein do not necessarily refer to a different embodiment. It is intended, for example, that covered or claimed subject matter include combinations of example embodiments in whole or in part.

[00016] In general, terminology may be understood at least in part from usage in context. For example, terms, such as "and", "or", or "and/or," as used herein may include a variety of meanings that may depend at least in part upon the context in which such terms are used. Typically, "or" if used to associate a list, such as A, B, or C, is intended to mean A, B, and C, here used in the inclusive sense, as well as A, B, or C, here used in the exclusive sense. In addition, the term "one or more" as used herein, depending at least in part upon context, may be used to describe any feature, structure, or characteristic in a singular sense or may be used to describe combinations of features, structures or characteristics in a plural sense. Similarly, terms, such as "a," "an," or "the," again, may be understood to convey a singular usage or to convey a plural usage, depending at least in part upon context. In addition, the term "based on" may be understood as not necessarily intended to convey an exclusive set of factors and may, instead, allow for existence of additional factors not necessarily expressly described, again, depending at least in part on context.

[00017] In one embodiment, a high buffering-capacity ("HBC") agent is incorporated into a sunscreen cosmetic or a sunscreen composition containing zinc oxides (ZnO) or titanium dioxides (TiO_2). In a further embodiment, the sunscreen cosmetic includes a composition for a cream, a lotion, a spray, a gel, a foam, a stick, or other topical composition that can be absorbed into skin. In another embodiment, the present invention is useful in any cosmetic or sunscreeen containing zinc oxides or titanium dioxides.

[00018] As used herein, the terms "high buffering-capacity agent", "HBC agent", and "buffering agent" means an agent, compound or material configured to react preferentially with an external acidic source or material and to inhibit (i.e., reduce zinc or titanium ion release such that the amount of zinc or titanium ion released from compositions with the buffering agent is less than the amount of zinc or titanium ion released from compositions that do not include the buffering agent) release of zinc ions from zinc oxides or release of titanium ions from titanium dioxides in their associated sunscreen cosmetics. In one embodiment, the HBC agent may reduce release of zinc or titanium ions by about 0.2% or more. In another embodiment, the HBC agent may reduce release of zinc or titanium ions by about 0.2% or less. In one embodiment, the HBC agent may reduce release of zinc or titanium ions by about 28% or more. In another embodiment, the HBC agent may reduce release of zinc or titanium ions by about 94% or less. This also includes absorptions of zinc ions and titanium ions already released in the mineral zinc oxide and titanium dioxide sunscreens to form water insoluble zinc and titanium complexes (e.g., $Zn_xCa(CO_3)_{x+1}$ or $Ti_xCa(CO_3)_{2x+1}$) on the surface of the HBC agents and, thus, reduce the bioavailability of zinc and titanium ions. The external acidic source or material is a biological

and/or environment source or material that is not part of the cosmetic itself, but mixes or otherwise comes in contact with the sunscreen cosmetic when it is applied to a user's skin. Examples of the external acidic material includes the user's skin, sweat, acid rain, an acidic beauty product, etc.

[00019] In sunscreen cosmetics, minerals, for example, zinc oxides or titanium dioxides, can be used as inorganic physical sun blockers. Furthermore, mineral based sunscreen cosmetics that include zinc oxides or titanium dioxides may be preferred over organic sunscreen cosmetics because mineral based sunscreen cosmetics may have limited skin penetration, less skin irritation and sensitization, and broad-spectrum UVB protection. Additionally, minerals such as zinc oxides and titanium dioxides have been considered relatively inert.

[00020] The inventor herein has discovered, surprisingly and unexpectedly, that when subjected to an acidic condition, zinc oxides and titanium dioxides in sunscreen cosmetics can be solubilized and release "free" zinc and titanium ions. As a result, conventional sunscreen creams, sunscreen lotions, and other sunscreen cosmetics containing zinc oxides or titanium dioxides could have toxic effects. The inventor herein has, surprisingly and unexpectedly, discovered that adding a buffer with a high buffering capacity can inhibit zinc and titanium solubilization and oxidant formation in sunscreen cosmetics.

[00021] In one embodiment, when the sunscreen cosmetic is exposed to an external acidic material or source (e.g., when it is applied to a person's skin, or when it comes in contact with sweat or acidic rain), the HBC agent is configured to react with the external acidic material or source and to inhibit release of zinc ions from zinc oxides and release of titanium ions from titanium dioxides in the sunscreen cosmetic. In one embodiment, the HBC agent is configured so as to interact with the external acid material or source and to neutralize same. In one embodiment, the HBC agent is configured to inhibit the external acidic material or source from significantly affecting (e.g., lowering more than 0.1 pH) the original pH of the sunscreen cosmetic (i.e., the pH of the sunscreen cosmetic prior to its exposure to the external acidic material or source or prior to its application to a person's skin). In one embodiment, the HBC agent is configured to inhibit the external acidic material or source and allows the sunscreen cosmetic to have a pH that remains substantially stable (e.g., the pH of the sunscreen cosmetic prior to its exposure to the external acid material or source or prior to its application to a person's skin remains within one pH upon exposure to an external acidic or source). In one embodiment, the HBC agent is configured to react with the external acidic material or source and to maintain the original pH of the sunscreen cosmetic substantially constant (e.g., within one pH of the original pH). In one embodiment, the HBC agent is configured to react with the external acidic source or material and

to maintain the pH of the sunscreen cosmetic substantially at neutral (e.g., pH range of about 6.5 to about 7.5). In one embodiment, the HBC agent is configured to react with the external acidic material or source and to maintain the pH of the sunscreen cosmetic substantially at neutral (e.g., pH range of about 6.5 to about 7.5) or near neutral (e.g., within two pH of pH 7). In one embodiment, the HBC agent is configured to react with the external acidic material or source and to maintain the pH of the sunscreen cosmetic between about 6.8 and about 7.2. In another embodiment, the HBC agent is configured to react with the external acidic material or source and to maintain the pH of the sunscreen cosmetic between about 6.5 and about 8. In other embodiments, the HBC agent is configured to react with the external acidic material or source and to maintain the pH of the sunscreen cosmetic between about 6 and about 10 or above 6.0.

[00022] In one embodiment, the HBC agent includes pearl powder and/or calcite powder. Pearl and calcite contain high levels of calcium carbonate ($CaCO_3$). In one embodiment, pearl powder may contain at least 90% calcium carbonate with the remaining percentage of the pearl powder including proteins, amino acids, and peptide. In another embodiment, the HBC agent may be any one of analogs of pearl or calcite powder (e.g., one with high alkaline cation from the second column of the periodic table (e.g., alkaline earth metals) but weak acid (e.g., pKa range from 3 to 6)). Non-limiting examples of such analogs include pearl powder, calcium carbonate, calcium citrate, calcium phosphate, calcium silicate, calcium molybdate, calcium tungstate, magnesium carbonate, magnesium phosphate, magnesium silicate, magnesium selenate, barium carbonate, barium phosphate, barium silicate, barium oxalate, barium molybdate, barium manganate, barium selenate, beryllium carbonate, beryllium phosphate, beryllium silicate, strontium carbonate, strontium phosphate, strontium silicate, strontium molybdate, strontium tungstate, strontium selenate, and a combination thereof. Pearl powder with a combination of calcium carbonate and amino acids, peptides, and proteins may be softer on skin than calcite and other HBC agents. Calcium-based HBC agents are more fine-tuned than pearl powder and calcite, and are particularly suitable because skin contains high levels of calcium ions. Additionally, dissolution of calcium carbonate will release calcium ion and carbon dioxide (CO_2), which has limited effects on the skin.

[00023] In one embodiment, the amount of the HBC agent included in the sunscreen cosmetic ranges from about 0.01% (w/w) to about 10% (w/w) relative to the overall weight of the cosmetic. In another embodiment, the HBC agent amount ranges from about 2.0% (w/w) to about 10% (w/w). In yet another embodiment, the HBC agent amount ranges from about 0.5% (w/w) to about 5% (w/w). In a further embodiment, the HBC agent amount ranges from about 1% (w/w) to about 2% (w/w).

[00024] In one embodiment, the sunscreen cosmetic can include conventional components that are included in a sunscreen cosmetic product. Such components are readily understood by a person of ordinary skill in the art. Examples of such components are disclosed in U.S. Patent Application Publication Nos. 2010/0183528 A1 published July 22, 2010; and 2012/0269753 A1 published October 25, 2012, the disclosures of all of which are incorporated herein by reference in their entireties.

[00025] In one embodiment, the HBC agent is in powder form. In one embodiment, the particle size of the HBC agent should be sufficiently small to enter the skin and to have high efficacy. In one embodiment, the sizes of the particles of the HBC agent range from about 0.05 μm to about 30 μm. In one embodiment, the sizes of the particles of the HBC agent range from about 0.1 μm to about 30 μm. In one embodiment, the sizes of the particles of the HBC agent range from about 0.3 μm to about 20 μm. In one embodiment, the sizes of the particles of the HBC agent range from about 0.3 μm to about 15 μm. In one embodiment, the sizes of the particles of the HBC agent range from about 0.3 μm to about 10 μm. In one embodiment, the sizes of the particles of the HBC agent range from 0.3 μm to about 5 μm. In one embodiment, the sizes of the particles of the HBC agent range from about 0.3 μm to about 2 μm. In one embodiment, the sizes of the particles of the HBC agent range from about 0.03 μm to about 1 μm. In other embodiments, the sizes of the particles of the HBC agent are greater than about 0.05 μm, about 0.1 μm, or about 0.3 μm and/or less than about 30 μm, about 20 μm, about 15 μm, about 10 μm, or about 5 μm.

[00026] In one embodiment, the HBC agent can be prepared in any method known in the art for preparing powder. For instance, pearls can be crushed, grinded or milled into fine powder using a conventional blender, grinder, mill, etc. In one embodiment, the HBC agent is added to a sunscreen cosmetic composition including zinc oxides and/or titanium dioxides to form a desired sunscreen cosmetic, such as a cream, a lotion, a spray, a gel, a foam, a stick, or other topical composition that can be absorbed into skin. In one embodiment, the sunscreen cosmetic composition can be made using any methods known in the art. For instance, a sunscreen cosmetic preparation (e.g., an emulsion) containing zinc oxides or titanium dioxides can be prepared in a conventional manner, and then the HBC agent can be added to and homogenized with the sunscreen composition prior to performing finishing steps, such an optional drying step, etc. In one embodiment, the HBC agent can be prepared in an aqueous phase or as an emulsion. For instance, the HBC agent can be prepared in an aqueous phase by pre-dispersing the HBC agent in an organic solvent, and then adding to an oil phase, such as pentylene glycol, before mixing with a water phase. In one embodiment, the HBC agent can be prepared as an emulsion by pre-

dispersing the HBC agent in a water phase and then adding to an oil phase. In one embodiment, the HBC agent in an aqueous phase or as an emulsion is added to a cosmetic composition containing including zinc oxides or titanium dioxides to form a desired sunscreen cosmetic, such as a cream, a lotion, a spray, a gel, a foam, a stick, or other topical composition that can be absorbed into skin.

[00027] Provided below are a more detailed discussion of the discoveries made by the inventor herein and various examples associated with same.

[00028] Sunscreen cosmetics have been used to provide protection against the effects of solar ultraviolet (UV) radiation, including both UVB and UVA radiation, on a user's skin. For example, UVA and UVB radiation can produce reactive oxygen species (ROS) that activate different matrix metalloproteinases, which damage collagen and other matrix proteins. This damage can result in loss of skin elasticity. The damage caused by UVA and UVB, collectively, is called photo-aging (i.e., formation of wrinkles on skin). In the last decennia, only sunscreen cosmetics containing both UVB and UVA filters have been produced. Minerals like zinc oxide and titanium dioxide can be used as inorganic physical sun blockers. They may be preferred above organic sunscreens because of limited skin penetration, absence of skin irritation and sensitization, and a broad-spectrum UV protection. Additionally, zinc oxides and titanium dioxides have been considered to be relatively inert.

[00029] Despite the foregoing conventional belief, the inventor herein has discovered, surprisingly and unexpected, that mineral based sunscreen cosmetics undergo chemical interactions with intrinsic and extrinsic environments. For example, the acidic pH in skin and in the sweat under the heat, and acid rain due to environmental pollution can solubilize the zinc oxides in the sunscreen cosmetics and release zinc ions for skin absorption as follows:

$$ZnO + 2H^{+} \text{------}\rightarrow Zn^{2+} + H_2O \qquad (1)$$

[00030] To a lesser degree, the acidic condition could lead titanium dioxide in the sunscreen cosmetics to release titanium ions for skin absorption as follows:

$$TiO_2 + 4H^{+} \text{------}\rightarrow Ti^{4+} + 2H_2O \qquad (2)$$

[00031] In addition, the inventor herein has discovered, surprisingly and unexpected, that zinc ions and titanium ions already released in mineral based sunscreen cosmetics can be absorbed by the HBC agents to form water insoluble zinc and titanium complexes (e.g., $Zn_xCa(CO_3)_{x+1}$ or $Ti_xCa(CO_3)_{2x+1}$). This absorption further reduces the bioavailability of zinc and titanium ions in the mineral based sunscreen cosmetics. The chemical reaction for the absorption of zinc ions can be written as follows:

$$Zn^{2+} + 2CaCO_3 \rightarrow ZnCa(CO_3)_2 + Ca^{2+}$$

[00032] The chemical reaction for the absorption of titanium ions can be written as follows:

$$Ti^{4+} + 3CaCO_3 \rightarrow TiCa(CO_3)_3 + 2Ca^{2+}$$

[00033] Since the natural opaqueness of these micro-sized mineral sunscreens can be eliminated without reducing their UV blocking efficacy by utilizing nano-sized zinc oxide and titanium dioxide particles, the sunscreen industry tend to use nanoparticles of the mineral sunscreens. Because of the smaller sizes, the larger surface areas allow more access to the acidic environment, which could make nanoparticles of zinc oxide and titanium dioxide even more susceptible to acid solubilization. Thus, the dissolved zinc and titanium ions may play an important role in the toxic effects of zinc oxide and titanium dioxide particles. For example, based on the experimental evidence from animal inhalation studies, titanium dioxide nanoparticles are classified as "possible carcinogenic to humans" by the International Agency for Research on Cancer and as occupational carcinogen by the National Institute for Occupational Safety and Health. Therefore, titanium dioxide is prohibited to use in a sprayed sunscreen in the European Union.

[00034] In addition, dissolution of zinc oxide and titanium dioxide can make these metal ions more bioavailable for cell uptake and, thus, cell toxicity. Another example is that zinc ions can help iron-catalyzed oxidation, known as Fenton reaction, to be more complete and more damaging.

EXAMPLE 1

[00035] The water solubility, and thus, bioavailability of zinc ions (Zn^{2+}) and titanium ions (Ti^{4+}) in commercial mineral sunscreen was examined. Figure 1 shows results from suspending a hydrating sunscreen from CeraVe in water at 75 mg/ml. The CeraVe sunscreen has a spectrum SPF 50 and contains 9% titanium dioxide (TiO_2) and 7% zinc oxide (ZnO). After suspension of the CerVe sunscreen, it released 2.7 mM Zn2+ ions and 3.7 mM Ti4+ ions. Assuming if all ZnO and TiO_2 were solubilized, these results indicate that the concentrations are equal to 0.28% ZnO and 0.39% TiO_2 particles solubilized. This gives a total concentration of Zn2+ and Ti4+ at 921 mM and 931 mM, respectively. It is interesting to note that mineral ZnO alone (IWAS, Japan) did not release Zn2+ in water (Figure. 1, 1st bar). These results suggest that mineral sunscreens, such as CeraVe, contain water soluble Zn2+ and Ti4+ ions that are readily bioavailable for toxic effects on the skin or after inhalation.

EXAMPLE 2

[00036] As shown in Figure 1, pure ZnO mineral as a raw material did not release Zn2+ in water. This was probably due to surface treatment. To further investigate this result, two pure

ZnO minerals (#1: IWAS from Japan and #2: K.S. Pearl from South Korea) were suspended in 40 ml of 50% tetraethyl glycol (TEG) in water. Figure 2 shows that both pure ZnO sunscreens #1 and #2 released large amounts of Zn2+ ions, 20.9 mM and 18.3 mM respectively. To demonstrate whether there is sufficient protection against the acidic pH of the skin, the sweat, and acid rain, 800 µl 100 mM HCl were used to titrate the suspensions. The pHs of the suspensions were slightly changed from 6.46 to 6.39 for sample #1 and 6.63 to 6.59 for sample #2, but the Zn2+ ion concentrations were increased from 20.9 mM to 24.2 mM or 15.8% for sample #1 and from 18.3 mM to 22.1 mM or 20.8% for sample #2, respectively. These results indicate that, despite surface treatment, which makes the mineral sunscreens such as ZnO and TiO_2 water insoluble, ZnO and TiO_2 can still interact with the acidic pH in a mixture of water and organic solvent, such as 50% TEG. These results are significant because any emulsion with a mixture of water phase and oil phase will render the mineral sunscreen accessible to acidic conditions This may result in solubilization of the mineral particles, which could lead to unsafe use of the mineral sunscreens.

EXAMPLE 3

[00037] The effects of adding calcite into mineral sunscreens, in particular calcite's effects on the buffering capacity of the mineral sunscreens, were examined. This Example investigates the effects of calcite on inhibiting Zn2+ release from ZnO in the presence of acid. Figure 3 shows that pure ZnO released large amounts of Zn2+ and titration of the suspension with 800 µl of 100 mM HCl further increased the amount of Zn2+ released by 10.6%. Interestingly, the addition of calcium carbonate prevented the acid-induced Zn2+ release and this prevention is calcium carbonate dose-dependent.

[00038] To further demonstrate that inhibited Zn2+ release by HCl is due to the preferred acid consumption by $CaCO_3$ over ZnO, the following formulation were examined: 0.7%, 2.1%, and 4.9% of $CaCO_3$ (W/W) mixed with a ZnO level equal to the ZnO level in the CeraVe mineral sunscreens at 7% (W/W). This resulted in weight ratios of $CaCO_3$ to ZnO at 10:1, 10:3, and 10:7. Additionally, a lower concentration of HCl at 50 mM for titration was used. Beside Zn2+ measurements, Ca2+ levels in the suspensions were also measured. Figure 4A shows that 50 mM HCl was able to increase the amount of released Zn2+ by only 3%. By comparing Zn2+ concentrations of the same pure ZnO mineral sunscreens without any treatments among Figures 2, 3, and 4, there were big variations of the background levels of Zn2+ ions, suggesting heterogeneity of the sample. However, the trend is the same. Interestingly, calcium carbonate inhibited the acid induced Zn2+ release. Figure 4B shows that lower concentration of HCl had a greater ability to release more Ca2+ in 0.7% $CaCO_3$ than in 2.1% and 4.9% $CaCO_3$, respectively, despite the fact that the absolute amount of HCl used in Figure 3 is the same as in Figure 4. These

results indicate that higher levels of $CaCO_3$ may be necessary for prolonged exposure to weak acid conditions. Moreover, because the amount of acid was limited (Fig. 4 A), it would be expected that amount of Ca2+ released in Figure 4B should be the same if calcite completely reacts with the limited acid and the amount of Zn2+ in Figure 4A should be the same as well. In contrast and unexpectedly, the amount of Ca2+ released was lower in higher concentration of calcite but the bioavailable Zn2+ was lower in higher concentrations of calcite. These results strongly indicate that, when the amount of acid is limited, the addition of calcite into the mineral sunscreen can absorb Zn2+ ions and Ti4+ ions on the surface of the calcite to form water insoluble zinc and calcium carbonate complexes (e.g., $Zn_xCa(CO_3)_{x+1}$), further reducing the amount of water soluble Zn2+ and Ti4+ in the sunscreens.

EXAMPLE 4

[00039] $CaCO_3$ has been shown that it can inhibit Zn2+ release from ZnO. It is unclear whether this inhibition can occur in commercially available sunscreens. Thus, base cream and the same cream containing 3% $CaCO_3$ was prepared so that these will be compatible when mixing with the mineral sunscreen. By mixing the base cream and 3% $CaCO_3$-containing base cream with the commercially available mineral sunscreen (CeraVe, SPF 50) at a weight ratio of 50:50 (w/w), the mixtures were suspended in 50% ethanol at 50 mg/ml overnight. Figure 5 shows that the mineral sunscreen released Zn2+ and Ti2+ in ethanol as previously observed in TEG. Base cream had no significant effect on Zn2+ and Ti4+ release. Interestingly, 3% $CaCO_3$ significantly reduced levels of Zn2+ and Ti4+. These results indicate that premixing of $CaCO_3$ with mineral sunscreens will have the ability to inhibit Zn2+ and Ti4+ release and thus, reduce their bioavailability and toxicity.

* * *

It will be understood by those having ordinary skill in the art and possession of the present disclosure that the embodiments described herein are merely exemplary in nature and that a person skilled in the art may make many variations and modifications thereto without departing from the scope of the present invention. All such variations and modifications are intended to be included within the scope of the invention.

WHAT IS CLAIMED IS:

1. A sunscreen composition for application to a user's skin, comprising a mineral including at least one of: zinc oxide, titanium dioxide, or a combination thereof; and a high buffering-capacity agent configured to react with an external acidic source coming in contact with said sunscreen composition and to inhibit release of zinc ions from said zinc oxide and/or to inhibit release of titanium ions from said titanium dioxide.

2. The sunscreen composition of Claim 1, wherein said high buffering-capacity agent includes at least one of pearl powder, calcium carbonate, calcium citrate, calcium phosphate, calcium silicate, calcium molybate, calcium tungstate, magnesium carbonate, magnesium phosphate, magnesium silicate, magnesium selenate, barium carbonate, barium phosphate, barium silicate, barium oxalate, barium molybate, barium manganate, barium selenate, beryllium carbonate, beryllium phosphate, beryllium silicate, strontium carbonate, strontium phosphate, strontium silicate, strontium molybate, strontium tungstate, strontium selenate, or a combination thereof.

3. The sunscreen composition of Claim 1, wherein said high buffering-capacity agent includes pearl powder having a size ranging from about 0.05 μm to about 30 μm.

4. The sunscreen composition of Claim 1, wherein said high buffering-capacity agent is included in said sunscreen composition in an amount ranging from about 0.01% (w/w) to about 10% (w/w).

5. The sunscreen composition of Claim 1, wherein said high buffering-capacity agent is included in said sunscreen composition in an amount ranging from about 1% (w/w) to about 2% (w/w).

6. The sunscreen composition of Claim 1, wherein said high buffering-capacity agent is configured to react with the external acidic source for maintaining a pH level of said sunscreen cosmetic above 6.0.

7. The sunscreen composition of Claim 1, further comprising at least one of: a composition for a cream, a lotion, a spray, a gel, a foam, or a stick.

8. The sunscreen composition of Claim 1, wherein the external acid source comprises at least one of: a user's skin, a user's sweat, acid rain, or an acidic beauty product.

9. The sunscreen composition of Claim 1, wherein the high buffering-capacity agent is prepared in an aqueous phase.

10. A sunscreen composition, comprising:

a mineral; and

a buffering agent comprising a weak acid, wherein the composition has a pH level that remains substantially stable upon exposure to an external acidic source.

11. The sunscreen composition of Claim 10, wherein the mineral comprises at least one of: zinc oxide, titanium dioxide, or a combination thereof.

12. The sunscreen composition of Claim 10, wherein said buffering agent includes at least one of pearl powder, calcium carbonate, calcium citrate, calcium phosphate, calcium silicate, calcium molybate, calcium tungstate, magnesium carbonate, magnesium phosphate, magnesium silicate, magnesium selenate, barium carbonate, barium phosphate, barium silicate, barium oxalate, barium molybate, barium manganate, barium selenate, beryllium carbonate, beryllium phosphate, beryllium silicate, strontium carbonate, strontium phosphate, strontium silicate, strontium molybate, strontium tungstate, strontium selenate, or a combination thereof.

13. The sunscreen composition of Claim 10, wherein said buffering agent includes pearl powder having a size ranging from about 0.05 μm to about 30 μm.

14. The sunscreen composition of Claim 10, wherein said buffering agent is included in said sunscreen composition in an amount ranging from about 0.01% (w/w) to about 10% (w/w).

15. The sunscreen composition of Claim 10, wherein said buffering agent is included in said sunscreen composition in an amount ranging from about 1% (w/w) to about 2% (w/w).

16. The sunscreen composition of Claim 10, wherein said buffering agent is configured to react with the external acidic source for maintaining the pH level of said topical sunscreen cosmetic above 6.0.

17. The sunscreen composition of Claim 10, further comprising at least one of: a composition for a cream, a lotion, a spray, a gel, a foam, or a stick.

18. The sunscreen composition of Claim 10, wherein the external acid source comprises at least one of: a user's skin, a user's sweat, acid rain, or an acidic beauty product.

19. The sunscreen composition of Claim 10, wherein the buffering agent is prepared in an aqueous phase.

20. A method for inhibiting toxic effects caused to a user's skin by a sunscreen composition containing a mineral, the method comprising:

applying a sunscreen composition to the user's skin, wherein the sunscreen composition comprises a mineral including at least one of: zinc oxide, titanium dioxide, or a combination thereof, and a buffering agent, the buffering agent reacting with an external acidic source coming in contact with the sunscreen composition and inhibiting release of zinc ions from the zinc oxide and/or inhibiting release of titanium ions from the titanium dioxide.

21. The method of Claim 20, wherein the buffering agent reacts with the external acidic source such that the pH level of the sunscreen composition remains substantially stable despite exposure to the external acidic source.

22. The method of Claim 20, wherein said buffering agent includes at least one of pearl powder, calcium carbonate, calcium citrate, calcium phosphate, calcium silicate, calcium molybate, calcium tungstate, magnesium carbonate, magnesium phosphate, magnesium silicate, magnesium selenate, barium carbonate, barium phosphate, barium silicate, barium oxalate, barium molybate, barium manganate, barium selenate, beryllium carbonate, beryllium phosphate, beryllium silicate, strontium carbonate, strontium phosphate, strontium silicate, strontium molybate, strontium tungstate, strontium selenate, or a combination thereof.

23. The method of Claim 20, wherein said buffering agent is prepared in an aqueous phase.

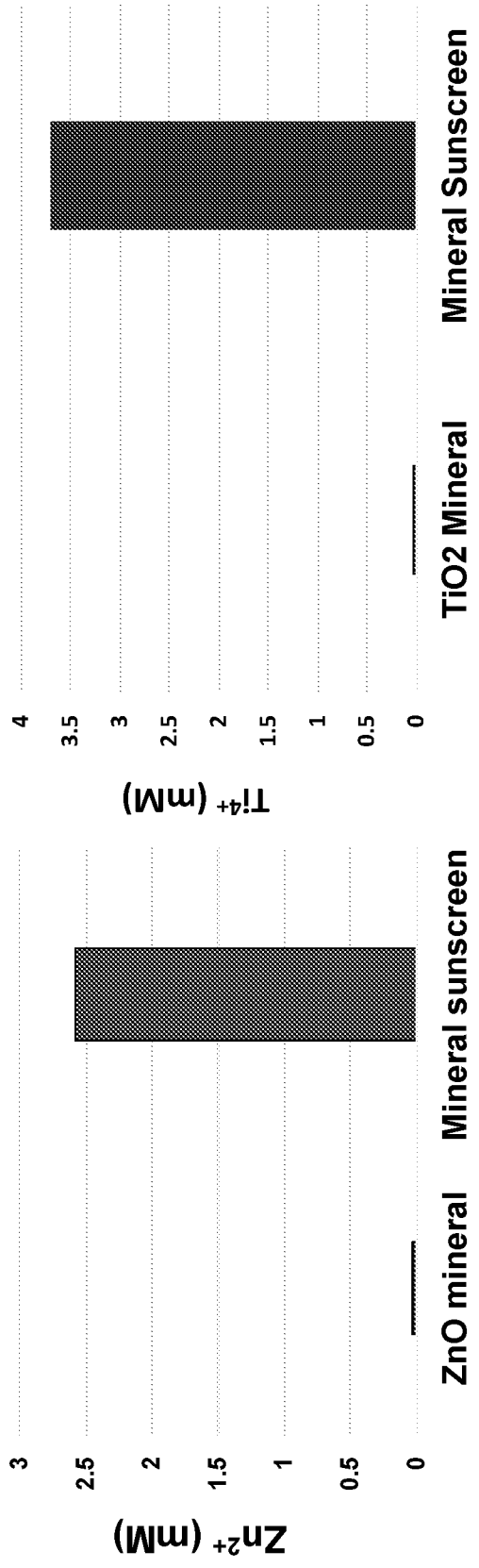
Zn^{2+} (mM)
3
2.5
2
1.5
1
0.5
0
ZnO mineral
Mineral sunscreen
Ti^{4+} (mM)
4
3.5
3
2.5
2
1.5
1
0.5
0
TiO2 Mineral
Mineral Sunscreen

Figure 1

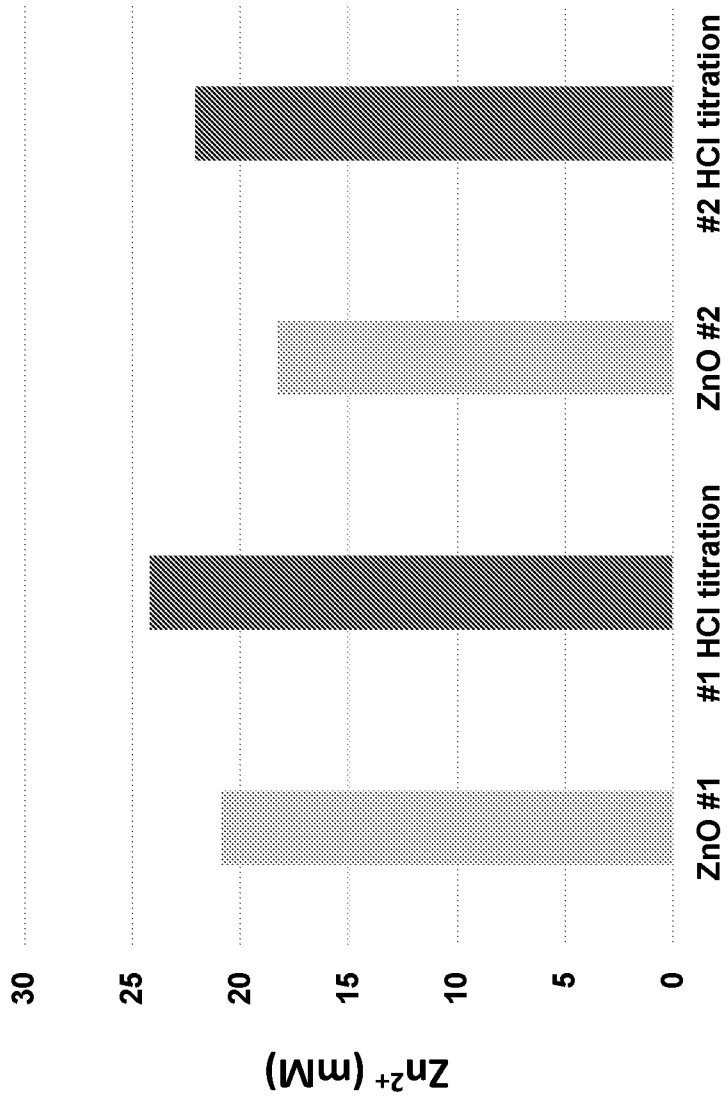
Zn^{2+} (mM)
30
25
20
15
10
5
0
ZnO #1
#1 HCl titration
ZnO #2
#2 HCl titration

Figure 2

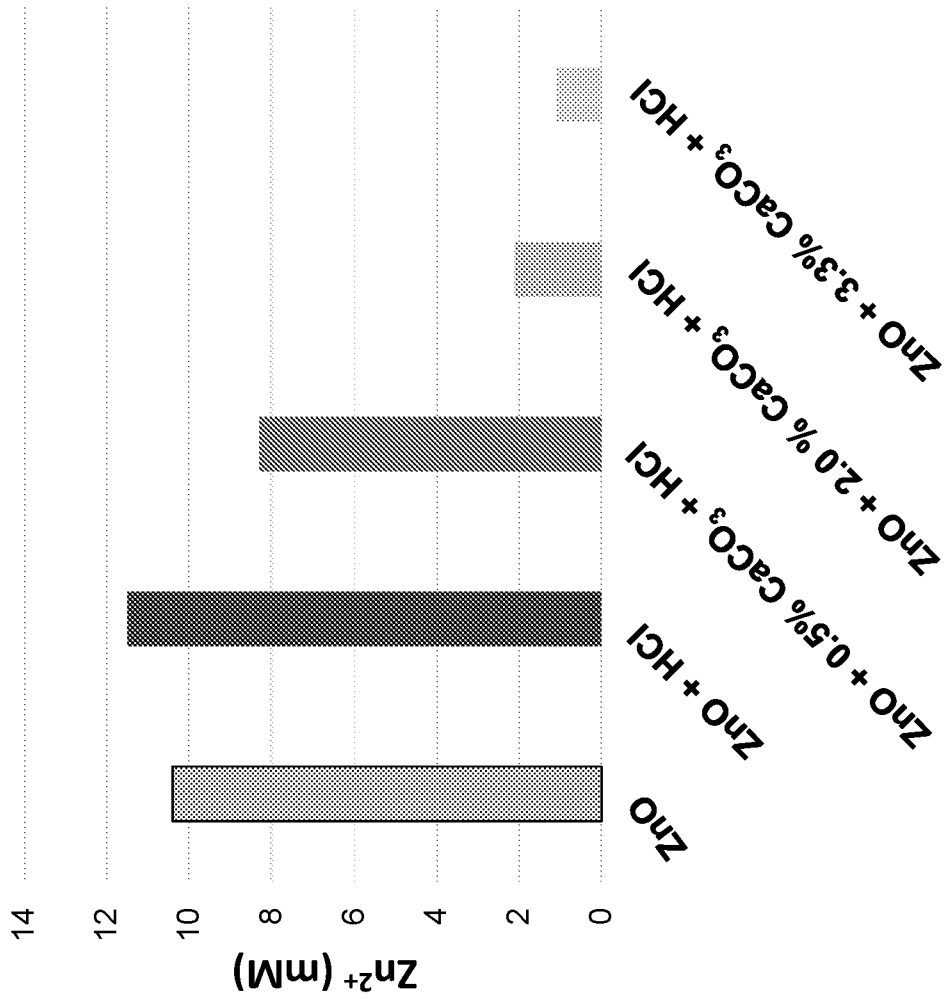
Zn^{2+} (mM)
0
2
4
6
8
10
12
14
ZnO
ZnO + HCl
ZnO + 0.5% $CaCO_3$ + HCl
ZnO + 2.0 % $CaCO_3$ + HCl
ZnO + 3.3% $CaCO_3$ + HCl

Figure 3

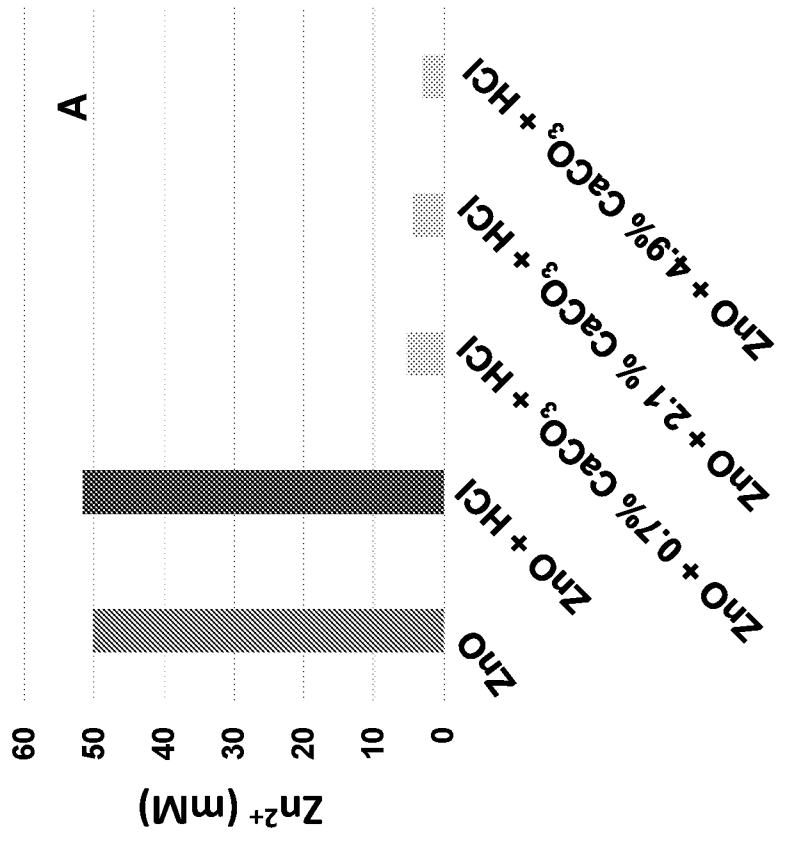

Figure 4A

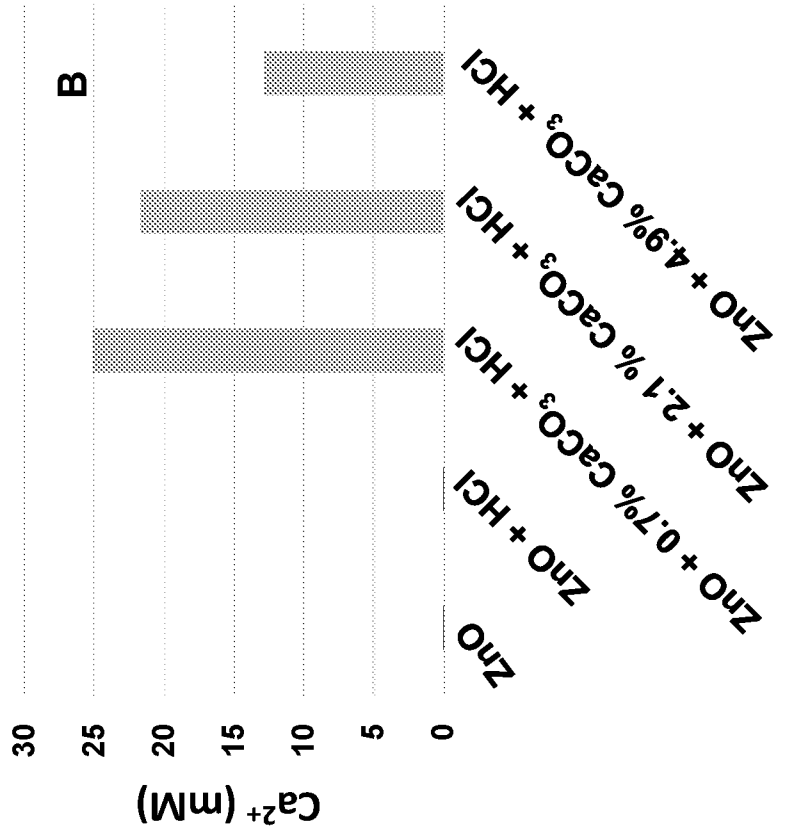

Figure 4B

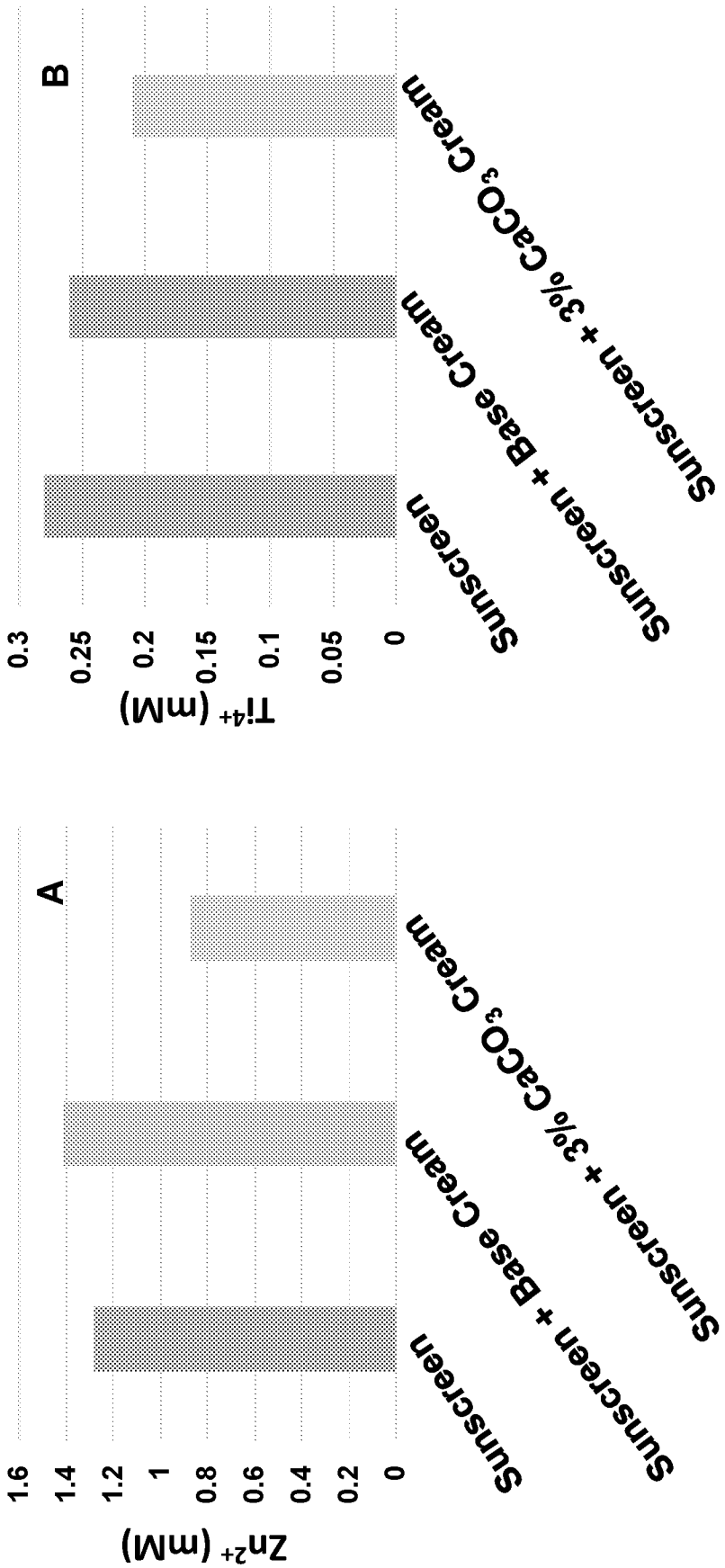
A
Zn^{2+} (mM)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Sunscreen
Sunscreen + Base Cream
Sunscreen + 3% $CaCO_3$ Cream
B
Ti^{4+} (mM)
0.3
0.25
0.2
0.15
0.1
0.05
0
Sunscreen
Sunscreen + Base Cream
Sunscreen + 3% $CaCO_3$ Cream

Figure 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/033745

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61K8/19 A61K8/27 A61K8/29 A61K8/98 A61Q17/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61K A61Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data, BIOSIS, EMBASE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	CN 106 852 867 A (ANHUI TANXIN TECH CO LTD) 16 June 2017 (2017-06-16) claims; examples -----	1-19
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	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
14 October 2021	25/10/2021

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/033745

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No
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