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(71) Applicant: **ARBONNE INTERNATIONAL, LLC** [US/US]; 9400 Jeronimo Road, Irvine, CA 92618 (US).

(72) Inventors: **BRADLEY, Christopher, Michael**; 11 Gavilan Road, Orinda, CA 94563 (US). **GROVE, Robert, E.**; 28 Grey Eagle Court, Pleasanton, CA 94566 (US). **CRARER, Alan, Scott**; 714 Lighthouse Avenue, Santa Cruz, CA 95060 (US). **TILLEY, Jeffrey, Alan**; 207 Redwood Drive, La Honda, CA 94020 (US). **BIANCHINI, Robert, J.**; 32622 Balearic Road, Dana Point, CA 92629 (US). **MATRAVERS, Peter**; 28102 Tefir, Mission Viejo, CA 92692 (US).

(74) Agents: **RYAN, Michael** et al.; Morgan Lewis & Bockius LLP, 1701 Market Street, Philadelphia, PA 19103 (US).

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(54) Title: DEVICES AND TARGETED METHODS FOR SKIN CARE TREATMENT

(57) Abstract: In one embodiment there is a handheld skin care appliance including an ultrasound source and at least one heat source separate from the ultrasound source. The appliance may also include an appliance tip coupled to the ultrasound source and coupled to the heat source in a configuration to apply through the appliance tip ultrasound waves in a frequency range of about 100 kHz to about 1 MHz and heat at a temperature in a range of about 30°C to about 40°C.

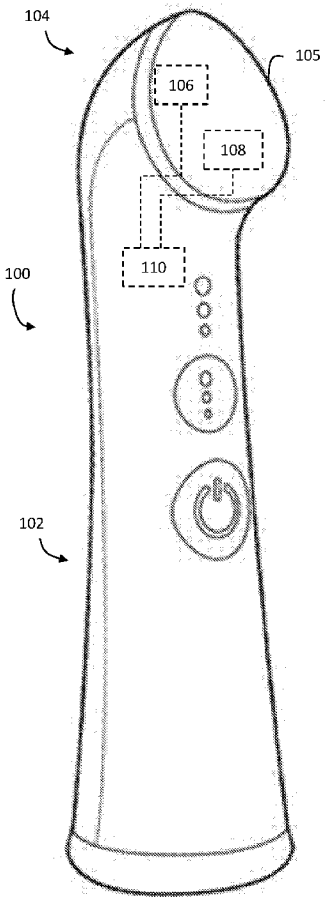


Fig. 1

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TITLE OF THE INVENTION

[0001] Devices and Targeted Methods for Skin Care Treatment

CROSS-REFERENCE TO RELATED APPLICATION

[0002] This application is an international application claiming the benefit of U.S. Provisional Application No. 62/280,428 filed January 19, 2016, the contents of which is incorporated herein by reference in its entirety.

BACKGROUND

[0003] The present invention generally relates to skin care treatment and, more particularly, to devices and methods for improved skin care treatment.

[0004] Skin is the largest organ in the body. It functions as the first point of human to human contact, acts as a barrier to environmental insult, regulates body temperature and cushions the body. Skin changes its physiology over our entire human lifecycle. From the moment of birth to our death, skin is undergoing regenerative changes and cell turnover. Skin is undergoing constant attack from external agents, environmental assaults, insects, fungi, etc. During this time, the skin loses its beauty and homogeneity. Beautiful, homogenous skin is important for human psychology, social interaction, reproduction and overall health and wellness. In order to keep skin healthy, it is necessary to treat and protect it.

[0005] Society has learned to deliver topical agents (e.g., chemicals, botanicals, natural extracts, or other ingredients) to skin as part of its daily health and hygiene regiment. A topical skin care or medicinal product can be effective when its beneficial substances can get inside skin cells or into the area surrounding the cells, affecting the skin in a way that improves its metabolism, health, wellness or overall appearance. Thus, it is generally desirable to allow selected active substances to diffuse or penetrate to various levels of the skin in order to improve pharmaceutical or beauty results.

[0006] The skin is composed of multiple layers; the epidermis, dermis, and hypodermis cover underlying tissues. The epidermis contains further layers, and serves as an outer barrier to water, pathogens, and the like. However, different layers of the skin can be difficult to penetrate. One such layer is the stratum corneum. This outer keratinous layer of the skin has about 20 layers of skin cells which are particularly difficult to penetrate due to the presence of lipids and complex structural proteins.

[0007] Certain topicals can penetrate the stratum corneum. However, some topicals fundamentally alter the skin layers so they are no longer effective to protect the body against environmental insults, cushion the body and regulate water loss and body temperature.

[0008] Thus, there exists a need to maximize the penetration effectiveness of topicals and improve skin health by overcoming the inherent barrier function of the stratum corneum without fundamentally altering the protective and metabolic functions of the skin layers.

SUMMARY

[0009] In one embodiment, there is a handheld skin care appliance including: an ultrasound source; at least one heat source separate from the ultrasound source; an appliance tip coupled to the ultrasound source and coupled to the heat source in a configuration to apply through the appliance tip ultrasound waves in a frequency range of about 100 kHz to about 1 MHz and heat at a temperature in a range of about 30°C to about 40°C.

[0010] In one embodiment, there is a handheld skin care appliance comprising: an ultrasound source comprising a piezoelectric transducer; at least one heat source separate from the ultrasound source; an appliance tip coupled to the ultrasound source and coupled to the heat source, and wherein the transducer and appliance tip produce an ultrasound field having a shape substantially similar to the shape of the appliance tip.

[0011] In one embodiment, there is a handheld skin care appliance comprising: an ultrasound source comprising a piezoelectric transducer that produces both ultrasound and heat; at least one heat source separate from the piezoelectric transducer; an appliance tip coupled to the ultrasound source and coupled to the heat source; and a microcontroller configured to adjust the electrical power to the heat source to maintain the appliance tip at a set temperature while minimizing the electrical power to said heat source.

[0012] In a further embodiment, the ultrasound source is configured to deliver a peak power level and an average power level to achieve a Mechanical Index of less than 0.5 and a Thermal Index Cranium of less than 2.0.

[0013] In a further embodiment, the appliance tip is coupled to the ultrasound source in a configuration that delivers ultrasound through the appliance tip at a level in the range of about 200 kHz to about 500 kHz.

[0014] In a further embodiment, the peak ultrasound power level is less than 2 watts and the average ultrasound power level is less than 250 milliwatts.

[0015] In a further embodiment, there are two heat sources that are disposed proximate to the appliance tip and the appliance tip includes an aluminum output surface.

[0016] In a further embodiment, the aluminum output surface includes a texture configured to define a medicament reservoir.

[0017] In a further embodiment, the appliance further comprises control circuitry configured to activate the ultrasound source and the heat source through states that include one or more of: emitting ultrasound only, emitting heat only, emitting ultrasound and heat simultaneously, emitting ultrasound followed by heat; and emitting heat followed by ultrasound.

[0018] In a further embodiment, the control circuitry is configured to vary a voltage applied to the ultrasound source to vary the ultrasound waves emitted from the ultrasound source.

[0019] In a further embodiment, the control circuitry is configured to vary a duty cycle of the voltage applied to the ultrasound source to vary the ultrasound waves emitted from the ultrasound source.

[0020] In a further embodiment, the control circuitry is configured to detect a resonant frequency of the ultrasound source and vary at least one of: the voltage and the duty cycle applied to the ultrasound source.

[0021] In a further embodiment, the control circuitry is configured to detect a load impedance of the ultrasound source and vary at least one of: the voltage and the duty cycle applied to the ultrasound source.

[0022] In a further embodiment, the control circuitry is configured to store usage information of the skin care appliance.

[0023] In a further embodiment, the control circuitry is configured to transmit usage information of the skin care appliance to a remote device.

[0024] In a further embodiment, the temperature of said appliance tip may be adjusted while the appliance tip is contacting the skin of a user.

[0025] In a further embodiment, said temperature adjustment is made by the user holding the skin care appliance using a hand that is holding the skin care appliance.

[0026] In a further embodiment, the ultrasound source is configured to deliver a peak power level and an average power level to achieve an output Mechanical Index (MI) of less than 0.23 and a Thermal Index Cranium (TIC) of less than 1.0.

[0027] In a further embodiment, the ultrasound source delivers ultrasound at a frequency in the range of about 100 kHz but less than 1 MHz.

[0028] In a further embodiment, the ultrasound source is circular and the appliance tip has a teardrop shape that causes a circular pattern of ultrasound waves emitted from the ultrasound source to have a non-circular shape after passing through the appliance tip.

[0029] In a further embodiment, the non-circular shape is a teardrop shape.

[0030] In a further embodiment, the appliance tip has at least one of: grooves, chevrons and surface features.

[0031] In a further embodiment, the skin care appliance weighs less than 7 ounces.

[0032] In a further embodiment, the appliance further comprising: a temperature sensor coupled to the appliance tip to measure the temperature of the output surface of the appliance tip, the control circuitry configured to cause the heat source to emit a selected amount of heat based on the measured temperature.

[0033] In a further embodiment, the appliance further comprising: a haptic feedback device configured to provide haptic feedback when ultrasound waves are applied through the appliance tip.

[0034] In a further embodiment, said haptic feedback is provided for at least one of the following events: toggling ultrasound on or off; toggling heat on or off; selecting a level of ultrasound or heat; initiating applying ultrasound or heat, completing applying ultrasound or heat, expiration of a selected time duration of ultrasound or heat.

[0035] In a further embodiment, the ultrasound source is a single disk-type piezoelectric transducer.

[0036] In a further embodiment, the ultrasound source is a ring-shaped piezoelectric transducer.

[0037] In a further embodiment, the appliance further comprising: a battery power source coupled to the ultrasound source and the heat source and configured to power the ultrasound source, the heat source and the control circuitry.

[0038] In one embodiment, there is a method of permeating skin with a selected agent comprising: applying a topical formulation to a portion of an outer layer of skin, wherein the topical formulation includes the selected agent; applying ultrasound to the portion of the outer layer of skin at a frequency in the range of about 100 kHz to about 1 MHz from an ultrasound source; and applying heat to the portion of the outer layer of skin within a temperature range of about 30°C to about 40°C.

[0039] In one embodiment there is a method of treating skin using a handheld skin care appliance, comprising: applying ultrasound to the skin using an ultrasound source comprising a piezoelectric transducer and an appliance tip, the appliance tip being coupled to the ultrasound source; applying heat to the skin using at least one heat source separate from the ultrasound source

and the appliance tip, the appliance tip being coupled to the heat source; producing a teardrop-shaped ultrasound field emitted from the appliance using the piezoelectric transducer having a circular shape and the appliance tip having a teardrop shape.

[0040] In one embodiment, there is a method of treating skin using a handheld skin care appliance comprising: applying ultrasound and heat either directly or indirectly to the skin using an ultrasound source comprising i) a piezoelectric transducer that produces both ultrasound and heat and ii) an appliance tip coupled to the ultrasound source; applying heat using i) at least one heat source separate from the piezoelectric transducer and ii) the appliance tip coupled to the at least one heat source; and adjusting electrical power to the heat source to maintain the appliance tip at a set temperature while minimizing the electrical power to said heat source using a microcontroller.

[0041] In a further embodiment, applying ultrasound further comprises delivering a peak power level and an average power level to achieve a Mechanical Index of less than 0.5 and a Thermal Index Cranium of less than 2.0.

[0042] In a further embodiment, the selected agent includes molecules that penetrate one or more layers of the skin in response to the application of ultrasound and heat to the portion of the outer layer skin.

[0043] In a further embodiment, the selected agent permeates the skin to a greater degree relative to the permeation obtained using an otherwise identical method that does not include the steps of applying ultrasound and/or applying heat.

[0044] In a further embodiment, the selected agent permeates the skin to a greater degree when compared to the permeation of the selected agent when a higher frequency ultrasound application is employed.

[0045] In a further embodiment, the topical formulation comprises a selected agent having a molecular weight of at least 200 Daltons, 500 Daltons, or at least 1000 Daltons.

[0046] In some embodiments, the stratum corneum layer of skin is resistant to penetration by topical application of the selected agent without the use of heat/ultrasound.

[0047] In a further embodiment, the penetration is through at least 50% of the stratum corneum.

[0048] In a further embodiment, the heat and ultrasound are applied according to one or more of: i) simultaneously, ii) heat followed by ultrasound; iii) ultrasound followed by heat; iv) prior to application of the topical formulation; v) after application of topical formulation; vi) application of topical between the application of heat and application of ultrasound, and vii) alternating between application of heat for approximately 30 seconds, followed by application of ultrasound for 30 seconds.

[0049] In a further embodiment, the selected agent comprises lipophilic ingredients.

[0050] In a further embodiment, the selected agent comprises hydrophilic ingredients.

[0051] In a further embodiment, the selected agent comprises skin protectants.

[0052] In a further embodiment, the selected agent comprises pharmacologically active ingredients.

[0053] In a further embodiment, the selected agent comprises antibacterial and antifungal agents.

[0054] In a further embodiment, the topical formulation is formulated to improve penetration of the selected agent into the skin when applying ultrasound or heat relative to penetration of the selected agent without applying ultrasound or heat.

[0055] In a further embodiment, an ultrasound source of a skin care appliance is configured to apply the ultrasound.

[0056] In a further embodiment, a heat source of the skin care appliance is configured to apply the heat.

[0057] In a further embodiment, control circuitry of the skin care appliance is configured to cause the ultrasound source to apply the ultrasound and the heat source to apply the heat.

[0058] In a further embodiment, the control circuitry varies a voltage applied to the ultrasound source to vary the ultrasound produced by the ultrasound source.

[0059] In a further embodiment, the control circuitry varies a duty cycle of the voltage applied to the ultrasound source to vary the ultrasound produced by the ultrasound source.

[0060] In a further embodiment, the control circuitry is configured to detect a resonant frequency of the ultrasound source and vary at least one of: the voltage and the duty cycle applied to the ultrasound source.

[0061] In a further embodiment, the control circuitry is configured to detect a load impedance of the ultrasound source and vary at least one of: the voltage and the duty cycle applied to the ultrasound source.

[0062] In a further embodiment, the control circuitry is configured to store usage information of the skin care appliance.

[0063] In a further embodiment, the control circuitry is configured to transmit usage information of the skin care appliance.

[0064] In a further embodiment, the method further comprising adjusting the temperature within the temperature range while the appliance tip is contacting the skin of a user.

[0065] In a further embodiment, the user holding a skin care appliance applying the ultrasound and the heat adjusts the temperature using a hand that is holding the skin care appliance.

[0066] In a further embodiment, a skin care appliance applying the ultrasound is configured to deliver a peak power level and an average power level to achieve an output Mechanical Index (MI) of less than 0.23 and a Thermal Index Cranium (TIC) of less than 1.0.

[0067] In a further embodiment, a frequency of the ultrasound is in a range of about 100 kHz to about 1 MHz.

[0068] In a further embodiment, a profile of the ultrasound has a teardrop shape.

[0069] In a further embodiment, the method further comprising: measuring the temperature of the output surface of the appliance tip and adjusting the heat applied to the skin of the user based on the measured temperature.

[0070] In a further embodiment, the method further comprising: providing haptic feedback to the user when applying the ultrasound.

[0071] In a further embodiment, said haptic feedback is provided for at least one of the following events: toggling ultrasound on or off; toggling heat on or off; selecting a level of ultrasound or heat; initiating applying ultrasound or heat, completing applying ultrasound or heat, expiration of a selected time duration of ultrasound or heat.

[0072] In a further embodiment, wherein the delivery of the topical (or selected agent) into the skin increases by 25-300% compared to application of topical alone, as measured by rate, volume, or concentration.

[0073] In a further embodiment, the topical formulation is in a form selected from the group consisting of a cream, liquid, serum, gel, stick, impregnated fabric, and powder.

[0074] In a further embodiment, the topical formulation has a viscosity of one of: 10,000 cps to 1,000,000 cps; 50,000 cps to 500,000 cps and 100,000 cps to 200,000 cps.

[0075] In a further embodiment, the selected agent is selected from the group consisting of: an alpha hydroxy acid, vitamin B, vitamin C, an antibiotic drug, an anti-infective compound, an aqueous plant extract, an anti-acne compound, non-steroidal anti-inflammatory agent pain reducing agent, wound healing agent, a corticosteroid, vitamin A, vitamin D, vitamin E, an anti-inflammatory compound, a skin whitening ingredient, a sunscreen agent, and combinations thereof.

[0076] In a further embodiment, the selected agent is a cosmetic or a pharmaceutically-active substance.

[0077] In a further embodiment, the topical formulation is one of: is aqueous, and non-aqueous.

[0078] In a further embodiment, the selected agent is a medicament that crosses into a bloodstream of the user.

[0079] In a further embodiment, the selected agent is selected from the group consisting of miconazole, tolnaftate, clotrimazole, ketoconazole, hydrocortisone acetate, betamethasone, trimcinolonepolymyxin-B, bacitracin, neomycindiphenhydramine, acyclovir, and salts, complexes, and combinations thereof, acetylsalicylic acid, N-acetyl-para-aminophenol (acetaminophen), isobutylphenylpropanoic acid, and derivatives thereof, a pain reducing agent, a wound healing agent, and a hormonal agent.

[0080] In a further embodiment, the topical formulation is a fabric impregnated with a selected agent.

[0081] In a further embodiment, the fabric is impregnated with a surfactant or surfactant mixture.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0082] The foregoing summary, as well as the following detailed description of embodiments of the invention, will be better understood when read in conjunction with the appended drawings of an exemplary embodiment. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown.

[0083] In the drawings:

[0084] Figure 1 illustrates an exemplary device for topical delivery to a selected layer of a user's skin, according to at least one embodiment of the invention.

[0085] Figure 2 illustrates an exploded view of the device of Fig. 1.

[0086] Figure 3 is a plot illustrating the control behavior of a controller and the corresponding temperature of the applicator tip of the device of Fig. 1, according to at least one embodiment of the invention.

[0087] Figure 4 illustrates an exemplary shape of the applicator tip, according to at least one embodiment of the invention.

[0088] Figure 5A illustrates a profile of the ultrasound field emitted by a piezoelectric element after passing through a "teardrop" shaped applicator tip, according to at least one embodiment of the invention.

[0089] Figure 5B illustrates a profile of the ultrasound field emitted by a piezoelectric element after passing through a circular shaped applicator tip.

[0090] Figure 6 is a flow chart illustrating a method for using the device to treat the skin of the user according to at least one embodiment.

DETAILED DESCRIPTION

[0091] Referring to the drawings in detail, wherein like reference numerals indicate like elements throughout, there is shown in Figs. 1-6 a skin care treatment appliance (device), and method for treating the skin, generally designated, in accordance with exemplary embodiments of the present invention.

[0092] The physio-chemical characteristics of a selected agent or formulation component intended to penetrate the skin are factors contributing to its penetration. Solubility, molecular size, particle size, crystalline form, volatility and polarity may all influence penetration capability and rate. However, increased ingredient penetration is also possible when the ingredient, alone or in a formulation with other ingredients, is coupled with one or more embodiments of the device, described herein. Using one or more embodiments of the device disclosed herein, skin penetration of selected agent(s) can be augmented over what is possible without the device and methods in view of the selected agents' size, polarity and chemical characteristics that may otherwise limit skin penetration.

[0093] For example, vitamin C (L-ascorbic acid) is a topical agent whose effectiveness against wrinkles and fine lines, for example by stimulating collagen production, is backed by a fair amount of reliable scientific evidence. Unfortunately, the practical use of vitamin C in skin care presents some difficulties for a number of reasons. First, vitamin C is relatively unstable. When exposed to air, vitamin C solution undergoes oxidation and becomes not only ineffective but also potentially harmful (oxidized vitamin C may increase the formation of free radicals). Second, vitamin C products tend to irritate the skin of some people. Reducing irritation is possible, but methods of doing so markedly reduce skin penetration.

[0094] Formulation approaches can help solve the above problems to improve delivery of vitamin C or similar target agents into or across the desired layer(s) of the skin, for example by using an anhydrous vehicle (i.e. a topical base cream containing no water) or using polypeptides with Vitamin C along with one or more embodiments of the device, described herein. Polypeptides are very large molecules, and are unable to penetrate skin even when combined with formulated penetration enhancers or other vehicles. The device of the invention improves delivery of vitamin C or similar target agents into or across the desired layer(s) of the skin.

[0095] Furthermore, using one or more embodiments of the device disclosed herein, such molecules penetrate the skin and can enhance biological activity, such as rebuilding the collagen matrix, increase surface blood flow, improving skin elasticity and reducing the appearance of fine lines and wrinkles. Useful polypeptides include, but are not limited to: Acetyl Tetrapeptide-2; Palmitoyl Tripeptide-38; Palmitoyl Oligopeptide; Palmitoyl Tetrapeptide-7; Hexapeptide-10, etc.

[0096] **I. Device**

[0097] In some embodiments, there is disclosed a device that that is configured to effectively deliver a topical -selected agent to skin (e.g., human, mammalian, vertebrate). A selected agent comprises one or more desired molecules, moieties, and/or active ingredients, and may be delivered in a formulation comprising the selected agent and other active and inactive ingredients that comprise the topical. The effective delivery of the selected agent may include delivery to a selected layer of skin (e.g., to the nail bed, to the stratum corneum, into the stratum corneum, through the stratum corneum, or through the skin to the vasculature).

[0098] In one embodiment, use of the device permits a topically applied selected agent to penetrate the desired layers of skin without fundamentally altering the skin layers. For example, in one embodiment, a device may utilize ultrasound and heat at selected levels to achieve a desired penetration to, into (e.g., 50%, 90%) or through the stratum corneum. As a result, a selected agent that would otherwise not reach a site of action or effect, or reach it in lower concentrations, if merely applied topically without the use of the disclosed device, will now reach the site of action, whether at the stratum corneum or at a deeper layer of the skin, and/or maintain a sufficient concentration at the site for the required length of time to improve the effectiveness of the topical agents without permanently altering the skin layers.

[0099] Figure 1 illustrates an exemplary device 100 for topical delivery of a selected agent, according to at least one embodiment of the invention. In this embodiment, the device 100 includes a housing 102, and an applicator head 104 having an applicator tip 105. In some embodiments, the device 100 also includes an ultrasound emitter 106 and/or a heater 108. In some embodiments, a controller 110 is coupled to the ultrasound emitter 106 and the heater 108 and is configured to cause the ultrasound emitter 106 and the heater 108 to perform their respective functions. In one operational example, a topical composition containing a selected agent is applied to the skin either by placing the topical composition on the applicator tip 105 or by applying the topical directly to skin prior to applying the applicator to the topical-covered skin. The controller 110 is configured to cause the ultrasound emitter 106 to emit ultrasound energy through the applicator head 104. The controller 110 is also configured to cause the heater 108 to emit heat and warm the applicator 104.

In one embodiment, the combination of ultrasound and heat (e.g., at selected levels) results in greater topical deposition than either modality alone.

[00100] Figure 2 illustrates an exploded view of the device 100 of Fig. 1, according to at least one embodiment of the invention. In Fig. 2, the ultrasound emitter 106 and heater 108 are positioned in the applicator head 104. The controller 110 is coupled to the ultrasound emitter 106 and the heater 108 via leads 112a and 112b respectively. The controller 110 transmits an ultrasound drive signal via lead 112a to operate the ultrasound emitter 106. The controller 110 transmits a heater drive signal via 112b to operate the heater 108.

[00101] In some embodiments, the controller 110 can generate different ultrasound and heater drive signals with different sets of parameters (e.g., duty cycle, peak-to-peak voltage, peak-to-peak current).

[00102] By using a selected ultrasound and/or heater drive signal with a selected set of parameters, the controller 110 can cause the ultrasound emitter 106 and the heater 108 to deliver a topical to a selected layer of the skin. For example, an ultrasound and drive signal with one set of parameters may cause the ultrasound emitter 106 and the heater 108 to deliver a topical to the stratum corneum layer of the skin, while an ultrasound and drive signal with another set of parameters may cause the ultrasound emitter 106 and the heater 108 to deliver a topical through the stratum corneum layer, or other desired layer, of the skin. In another example, in some embodiments, as the ultrasound peak power, ultrasound average power, and/or emitted heat are increased; increased amounts of the target topical will be driven into and/or through the stratum corneum.

[00103] In some embodiments, the device 100 includes a power supply 114 (e.g., a battery) coupled to the controller 110. In some embodiments, the power supply 114 provides electrical power (e.g., low-voltage DC) to the controller 110. In some embodiments, the electrical power is a power supply signal (e.g., low-voltage DC signal). In some embodiments, the controller 110 then converts the electrical power to AC or DC drive power, as desired, and transmits this drive power to the ultrasound emitter 106 and the heater 108. In some embodiments, the drive power is the ultrasound and heater drive signals.

[00104] In some embodiments, the device 100 is lightweight (e.g., less than 7 ounces). This makes the device 100 easy to hold and maneuver when using the device 100.

[00105] **A. Ultrasound Emitter**

[00106] In some embodiments, the ultrasound emitter 106 emits low frequency ultrasound waves. Low frequency sound waves emitted from the device 100, and using the methods and/or topicals of

embodiments of the invention, help a variety of skin conditions, including aging skin, wrinkles, acne, rosacea, psoriasis, eczema, infections, hyperpigmentation, release of dead surface skin cells, loosening of comedones, and enhance the skin penetration of pharmaceutically active substances.

[00107] In some embodiments, ultrasound emitter 106 is configured to emit ultrasound waves at a power level in a low frequency range of about 20 kHz to about 1 MHz, of about 30 kHz to about 1 MHz, of about 40 kHz to about 1 MHz, of about 50 kHz to about 1 MHz, of about 60 kHz to about 1 MHz, of about 70 kHz to about 1 MHz, of about 80 kHz to about 1 MHz, of about 90 kHz to about 1 MHz, of about 100 kHz to about 1 MHz, of about 110 kHz to about 1 MHz, of about 120 kHz to about 1 MHz, of about 130 kHz to about 1 MHz, of about 140 kHz to about 1 MHz, of about 150 kHz to about 1 MHz, of about 175 kHz to about 1 MHz, of about 200 kHz to about 1 MHz, of about 300 kHz to about 1 MHz, of about 400 kHz to about 1 MHz, of about 500 kHz to about 1 MHz, of about 600 kHz to about 1 MHz, or of about 700 kHz to about 1 MHz, of about 750 kHz to about 1 MHz. In some embodiments, ultrasound emitter 106 is configured to emit ultrasound waves at a power level in a frequency range of about 300 kHz to about 350 kHz, of about 250 kHz to about 400 kHz, of about 200 kHz to about 500 kHz, of about 150 kHz to about 600 kHz, of about 100 kHz to about 700 kHz.

[00108] In some embodiments, the ultrasound emitter 106 emits ultrasound waves having a profile having a shape that is one of: circular-shaped, square-shaped, oval-shaped, or triangular-shaped. One of ordinary skill in the art would appreciate that different embodiments of the invention may have different shapes to those disclosed herein.

[00109] In some embodiments, the ultrasound emitter 106 includes a piezoelectric ceramic transducer. One of ordinary skill in the art would appreciate that, in other embodiments, other types of devices to emit ultrasound may be used, including flexible ribbon transducers.

[00110] In some embodiments, a piezoelectric ceramic transducer converts electrical energy to ultrasound energy through a scientific principle called the piezoelectric effect. When an electrical voltage is applied to the ceramic, mechanical deformations occur causing the transducer to vibrate and produce sound waves. In some embodiments, the electrical voltage is the ultrasound drive signal transmitted from the controller 110.

[00111] In some embodiments, the ultrasound drive signal is a low-voltage AC signal operating at a certain resonant frequency. When the ultrasound emitter 106 receives the ultrasound drive signal, the ultrasound emitter 106 produces ultrasound energy that propagates through the applicator head 104 towards the skin of the user at the resonant frequency.

[00112] In some embodiments, the device 100 uses relatively low values of ultrasound peak power and ultrasound average power (e.g., 60 milliwatts) to minimize any unintended biological effects on the user. In some embodiments, ultrasound emitter 106 emits ultrasound at a peak power level of approximately 2 watts, less than 2 watts, between 1 and 2 watts, approximately 1 watt, or less than 1 watt. In some embodiments, ultrasound emitter 106 emits ultrasound at an average power level of 250 milliwatts or of no greater than 250 milliwatts.

[00113] Without wishing to be bound to any theory of operation unless expressly stated in the appended claims, when skin is exposed to ultrasound, several effects may occur that assist skin penetration by a topical. For example, if the ultrasound power is sufficiently high, gas bubbles form. This is referred to as cavitation. Ultrasonic pulses penetrate into the skin, fluidizing the lipid-bilayer by the formation of the bubbles. The force of cavitation causes the formation of holes in the corneocytes, the enlarging of intercellular spaces and the disorder of stratum corneum lipids.

[00114] There are certain adverse biological effects that may occur at unsuitable ultrasound power levels. For example, temperature rise at the impedance discontinuity (i.e., the tissue/skull interface) can be an issue for ultrasound devices. Cavitation in the eye is another issue for ultrasound devices. These biological effects are tracked using the Thermal Index for Cranial Bone (TIC) and the Mechanical Index (MI), among other parameters, all as known in the art.

[00115] TIC is thermal index for bone at the surface which is used to measure temperature rise for ultrasound through the skull. In some embodiments, TIC values are based on estimates of acoustic energy necessary to create a temperature increase of 1 degree (i.e., a TIC=1) that results from a tissue model estimating a temperature rise of 1 degree Celsius.

[00116] In some embodiments, TIC = Power(mW)/[40*D(cm)], where D is the active diameter of the source. To determine the TIC of a device, the average ultrasound power is measured in a calibrated acoustic tank (a water-filled tank containing one or more hydrophones) and a formula involving the average power and source diameter is then employed to determine the TIC. This measurement technique is standard within the industry and is well known to those familiar with the art.

[00117] In some embodiments, MI is an ultrasound parameter for gauging cavitation risk in the eye. MI is defined at the derated peak negative pressure in MPa divided by the square root of the center frequency in MHz. To determine the MI, the same tank is used to determine the peak negative acoustic pressure, and a formula involving the peak negative acoustic pressure and the ultrasound frequency is then employed to determine the MI. This measurement technique is standard within the industry and is well known to those familiar with the art.

[00118] Additional information regarding physiotherapy standards can be found in the following documents:

[00119] 1. "Medical electrical equipment – Part 2-5: Particular requirements for the safety of ultrasonic physiotherapy equipment", International Electrotechnical Commission (IEC) Reference Number IEC 60601-2-5:2000(E)

[00120] 2. "Ultrasonics – Physiotherapy systems – Field specifications and methods of measurement in the frequency range 0.5 MHz to 5 MHz", International Electrotechnical Commission (IEC) Reference number IEC 61689:2007(E)

[00121] 3. 21 CFR 1050.10. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?FR=1050.10

[00122] 4. Acoustic Output Measurement Standard for Diagnostic Ultrasound Equipment, Revision 3," NEMA Standard Publication UD-2, National Electrical Manufacturers Association, 2004.

[00123] 5. "Standard for the Real-time Display of Thermal and Mechanical Acoustic Output Indices on Diagnostic Ultrasound Equipment, Revision 2" NEMA Standard Publication UD-3, National Electrical Manufacturers Association, 2004.

[00124] 6. "510(k) Guide for Measuring and Reporting the Acoustic Output of Diagnostic Ultrasound Medical Devices," Center for Devices and Radiological Health, FDA, 1985, and revised in 1989, 1990, 1991, 1993, 1994, 1997, 2008.

[00125] 7. "Medical electrical equipment-Part 2-37: Particular requirements for the basic safety and essential performance of ultrasonic medical diagnostic and monitoring equipment", International Electrotechnical Commission (IEC) Reference number IEC 60601-2-37:2007

[00126] 8. "Ultrasonics-Field characterization-Test methods for the determination of thermal and mechanical indices related to medical diagnostic ultrasonic fields", International Electrotechnical Commission (IEC) Reference number IEC 62359:2006

[00127] In some embodiments, firmware on device 100 is configured to vary the voltage and duty cycle such that the device 100 maintains an output MI and/or a TIC at a selected range. In some embodiments, the firmware is operable to detect an ultrasound frequency of a transducer and vary the voltage and/or duty cycle so that the device maintains an output mechanical index and/or an output thermal index in a selected range or peak. In some embodiments, the firmware is operable to detect a load impedance of a transducer and modify the voltage and/or duty cycle so that the device maintains an output mechanical index and/or an output thermal index in a selected range or peak. In some embodiments, firmware on device 100 is configured to adjust the peak-to-peak drive voltage

to the transducer 104 to maintain an output MI of the device 100 in a selected range or below a selected maximum; and/or adjust the average electrical power to the transducer 104 (for example, by adjusting the duty cycle) to maintain a TIC of the device 100 in a selected range or below a selected maximum.

[00128] In some embodiments, the maintained MI is 0.5, is up to 0.5, is 0.4, is up to 0.4, is 0.3, is up to 0.3, is 0.27, is up to 0.27, is 0.25, is up to 0.25, is 0.23, is up to 0.23, is 0.21, is up to 0.21; is 0.15, or is up to 0.15. The TIC is used, in some embodiments, as an estimate of the thermal effects of ultrasound. In some embodiments, the maintained TIC is 2.0, is less than 2.0, is 1.8, is less than 1.8, is 1.6, is less than 1.6, is 1.4, is less than 1.4, is 1.2, is less than 1.2, is 1.0, or is less than 1.0. At a TIC value of 1.0, the device 100 will produce a temperature rise at a bone-tissue interface of approximately 1.0 degree Celsius. Other values of TIC result in proportional changes in the interface temperature (e.g., 2.0 TIC results in 2.0 degree Celsius temperature rise). By maintaining the MI and/or the TIC within a desired range or below a select threshold, the device 100 can provide its intended therapeutic benefit without harming the tissue or the user.

[00129] **B. Heater**

[00130] In some embodiments, the heater 108 includes a plurality of resistive heating elements positioned throughout the applicator head 104. In some embodiments, the plurality of resistive heating elements are positioned on the inner surface of the applicator tip 105 so that, during operation, the resistive heating elements are positioned as close to the skin of the user as possible, without contacting the skin of the user. In some embodiments, the resistive heating elements are attachable to the applicator tip 105 using a high-thermal-conductivity epoxy to minimize thermal resistance between the heating elements and the applicator tip 105. The resistive heating elements emit heat in response to receiving a heater drive signal from the controller 110. By having a plurality of resistive heating elements disposed throughout the applicator head 104, the heater 108 can emit heat more uniformly and thereby increase the skin's absorption of the topical (e.g., an increase in fluidity of the stratum corneum lipids, an increase in diffusivity of molecules through the skin barrier).

[00131] In some embodiments, two or more heaters 108 are disposed in applicator head 104. The use of two or more heaters can facilitate uniform heating of the applicator tip 105.

[00132] In some embodiments, the device 100 maintains the applicator tip 105 at a certain temperature. In these embodiments, the heater 108 includes a temperature sensor (e.g., thermistor) positioned within the applicator head 104. The temperature sensor senses the temperature of the applicator tip 105 and transmits a temperature signal to the controller 110. The controller 110 may

then determine whether to adjust the heater drive signal based on the temperature signal from the temperature sensor. For example, if the temperature signal indicates that the temperature of the applicator tip 105 exceeds a temperature threshold (e.g., any desired set point between 30 and 40 degrees Celsius), the controller 110 can reduce the current of the heater drive signal, or cease transmitting a heater drive signal, to reduce the amount of heat emitted by the heater 108. Alternatively, if the temperature signal indicates that the temperature of the applicator tip 105 does not exceed the temperature threshold, the controller 110 can increase the current of the heater drive signal to increase the amount of heat emitted by the heater 108. As a result, a temperature feedback loop is created that allows the device 100 to maintain the applicator tip 105 at a constant temperature (e.g., a desired set point).

[00133] In some embodiments, to the extent that heat produced by the ultrasound transducer contributes to warming of the applicator tip 105, the controller 110 can reduce the current of the heater drive signal to maintain a certain temperature of the applicator tip 105.

[00134] Figure 3 illustrates a plot showing the control behavior of a controller 110 and the corresponding temperature of the applicator tip 105, according to at least one embodiment of the invention.

[00135] In the plot, the red trace indicates when the controller 110 supplies the heater drive signal to the heater 108. For example, in the time period from 0 to 30 seconds, the controller 110 is transmitting the heater drive signal to the heater 108. In the time period from 30 to 40 seconds, the controller 110 is not transmitting the heater drive signal to the heater 108. The plot further shows the controller 110 oscillating between transmitting and not transmitting the heater drive signal over the rest of the time period.

[00136] The yellow trace indicates the temperature of the applicator tip 105. For example, in the time period from zero (0) to thirty (30) seconds, while the controller 110 is transmitting the heater drive signal to the heater 108, the temperature of the applicator tip 105 is increasing from 22 degrees Celsius to 36 degrees Celsius. In the time period from 30 to 40 seconds, while the controller 110 is not transmitting the heater drive signal to the heater 108, the temperature of the applicator tip 105 is decreasing from 36 degrees Celsius to 35 degrees Celsius. The plot further shows the temperature of the applicator tip 105 oscillating between 35 degrees Celsius and 36 degrees Celsius based on whether the controller 110 is transmitting the heater drive signal to the heater 108.

[00137] In one embodiment, heater(s) 108 deliver temperatures of about 25°C to about 45°C, of about 30°C to about 40°C, or about 35°C.

[00138] **C. Applicator tip**

[00139] In some embodiments, the applicator tip 105 is composed of metal (e.g., aluminum) or metal alloy to improve thermal conductivity. In some embodiments, the applicator tip 105 has a thermal conductivity of at least 50 (W/m K). In some embodiments, the applicator tip 105 composed of metal alloy 6061-T6, having a thermal conductivity of approximately 152 (W/m K). In some embodiments, the applicator tip 105 is composed of A380, having a thermal conductivity of approximately 96 (W/m K). By having an applicator tip 105 with a thermal conductivity of at least 50 (W/m K), the device 100, in some embodiments, can maximize effectiveness of the topical and reduce the barrier function of the layers of the skin.

[00140] In some embodiments, the applicator tip 105 has a non-circular shape (e.g., teardrop, triangle). This allows a user to position the device 100 at certain portions of the face (e.g., near the nose and under the eyes) generally inaccessible to devices with circular shaped applicator tips of comparable surface area. Figure 4 illustrates an exemplary shape of the applicator tip 105, according to at least one embodiment of the invention.

[00141] Applicator tip 105 may include a textured surface. The textured surface may include reservoirs that are configured to retain a topical agent for application to skin. The textured surface may include depressions/protrusions oriented in parallel channels or evenly spaced discrete depressions/protrusions (e.g., geometric depressions, substantially circular depressions, irregularly shaped depressions, raised surface bumps of features, surface textures).

[00142] In some embodiments a membrane (e.g., impregnated paper, non-woven fabric, woven fabric, transparent membrane) is disposed between the applicator tip 105 and a topical formulation during use of the device 100. In some embodiments, the membrane may be pre-treated with a topical formulation. These embodiments may allow for cleansing and exfoliation of the skin or alternative delivery of active ingredients. These embodiments may also reduce evaporation rate for the topical formulation and allow more contact time to effectively apply the topical formulation to the skin. In these embodiments, the device 100 emits ultrasound waves and/or heat that propagate through the membrane to deliver a topical formation to select layers of the skin of the user.

[00143] **D. Teardrop shaped ultrasound**

[00144] As described above, in some embodiments, the device 100 includes a piezoelectric transducer (i.e., ultrasound emitter 106) to generate ultrasound energy that passes through the applicator tip 105. In some embodiments, the piezoelectric transducer is circular (e.g., to enable the proper vibrational modes necessary to produce ultrasound energy). However, one of ordinary skill in the art would appreciate that the piezoelectric transducer may have other shapes.

[00145] In some embodiments, the piezoelectric transducer produces an ultrasound energy field having a shape (e.g., circular shape) similar to the shape of the piezoelectric transducer. In some embodiments, the device 100 includes an applicator tip 105 having a shape (e.g., non-circular shape (e.g., a "teardrop" shape, elongated shape, oval shape, triangular shape, rectangular shape)) that is different from the shape of the piezoelectric transducer. In some embodiments, the applicator tip 105 is made of metal (e.g., aluminum). In some embodiments, when the ultrasound energy field passes through the applicator tip 105, the ultrasound field shape is altered by the shape of the applicator tip 105. For example, in embodiments where the applicator tip 105 has a "teardrop" shape, the shape of the ultrasound field after passing through the applicator tip 105 has "teardrop" shape as well, even if the ultrasound field had a different shape (e.g., circular) after emission by the piezoelectric transducer.

[00146] In some embodiments where the ultrasound energy field is based on (or a function of) the shape of the applicator tip 105, at least some of the ultrasound generated by the ultrasound emitter 106 and propagated towards the applicator tip 105 is reflected by the applicator tip 105 (e.g., the proximal (first) surface 105a and/or the distal (second) surface 105b of the applicator tip 105 (shown in Fig. 2)). In these embodiments, at least some portion of the reflected portion of the ultrasound is subsequently reflected by the ultrasound emitter 106 back toward and through the applicator tip 105. Portions of the ultrasound reflected from the second surface 105b may also be internally reflected from the first surface 105a. The multiple internal reflections within the applicator tip 105 propagate within the applicator head 104, filling to at least a partial extent the non-circular (e.g., teardrop) shape of the applicator tip 105. A portion of these internal reflections propagates through a substantial portion of the applicator tip 105, such that the device 100 produces a corresponding non-circular shape of the ultrasound field as a function of the profile shape of the applicator tip 105. Thus, the combination of the un-reflected (e.g., circular) ultrasound field, the shape of the applicator tip 105, and the multiple-internal reflection ultrasound field in the tissue form an ultrasound field having a similar shape (e.g., teardrop) to the shape of the applicator tip 105.

[00147] Figure 5A illustrates a profile of the ultrasound field emitted by an ultrasound emitter 106 (e.g., piezoelectric element) after passing through a "teardrop" shaped applicator tip 105 as shown in Fig. 4, according to at least one embodiment of the invention. Figure 5B illustrates a profile of the ultrasound field emitted by an ultrasound emitter 106 (e.g., a piezoelectric element) after propagating through a circular shaped applicator tip 105, for comparison. In Figs. 5A and 5B, the ultrasound field was measured using a diagnostic instrument known as Aureon developed by Acertara Acoustic Laboratories (Longmont, CO). As shown in Fig. 5A, the actual shape of the

ultrasound field appears to have a different shape (e.g., non-circular or "teardrop") compared to the ultrasound field in Fig. 5B. Instead the ultrasound field forms the shape of the applicator tip 105.

[00148] By producing an ultrasound energy field having a similar shape to the applicator tip 105, the benefits of the ultrasound output of the device 100 extend into the small facial region of the user (e.g., around the eyes and nose), so that these areas benefit not only from the heated applicator tip 105 but also by the presence of the ultrasound field as well.

[00149] **E. Drive signal programmable settings**

[00150] In some embodiments, the device 100 includes a plurality of pre-programmed settings to adjust the average power of the ultrasound energy and/or the amount of heat emitted by the device 100. These pre-programmed setting are selectable by a user during operation of the device 100. When one of the settings is selected, the controller 110 alters the ultrasound drive signal and/or the heater drive signal based on the selected setting. For example, the device 100 may be configured to include one or more pre-programmed settings for controlling levels of ultrasound average power. Alternatively, or additionally, the device 100 may be configured to include one or more pre-programmed settings for controlling the temperature of the applicator tip 105. As an example, in one embodiment, the device 100 may have Low, Medium, and High settings that are selected by a user. In this example, the three settings may all have the same average ultrasound power output, for example 60 milliwatts; but each has a different set point temperature for the applicator tip 105 such as 32, 34 or 36 degrees Celsius.

[00151] Due to varying manufacturing conditions, each skin care treatment device (e.g., device 100) may have different ultrasound energy and heat emission characteristics. In some embodiments, after the device 100 is assembled and individually tested, firmware of device 100 is configured to permit a user to vary the voltage delivered by device 100 and/or duty cycle delivered by device 100 to adjust the ultrasound energy and/or heat emission characteristics (e.g., peak-to-peak drive voltage, the drive voltage duty cycle) of the device 100. Either or both of these parameters may also be adjusted by a remote device (e.g., a smart phone) by modifying firmware on the controller 110 through either a wireless (e.g., Bluetooth) or wired interface connection. By allowing adjustment of the peak ultrasound power output of the device 100 after assembly (e.g., during manufacture), the ultrasound energy output of the device 100 can also be programmed to remain below a Mechanical Index (MI) value of e.g. 0.23, which ensures safe operation of the device 100 even in the eye area of the user. In a similar manner, by allowing adjustment of the duty cycle of the ultrasound output of the device 100 after assembly, the ultrasound energy output of the device 100 can be programmed to remain below a Thermal Index Cranium (TIC) of 1.0.

[00152] In some embodiments, the controller 110 may be programmed to cycle the emission of ultrasound energy and/or heat. For example, in some embodiments, the controller 110 may be programmed to cause the device 100 to perform at least one of: i) alternate between emitting ultrasound energy and emitting heat, ii) emit heat after emitting ultrasound energy, iii) emit ultrasound energy after emitting heat, iv) emit heat and/or ultrasound energy prior to application of the topical, v) emit heat and/or ultrasound energy after application of the topical, vi) emit heat and/or ultrasound energy between application of the topical, vii) consistently emitting ultrasound energy and intermittently emitting heat, viii) intermittently emitting ultrasound energy and consistently emitting heat and ix) alternating between application of heat for approximately 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, or 55 seconds, followed by application of ultrasound for 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, or 55 seconds. By cycling the emission of ultrasound energy and heat, the device 100 can maximize delivery of the topical by reducing the barrier function of the layers of the skin and impart a variety of cosmetic, beauty, health and wellness and pharmacological benefits to the skin.

[00153] In some embodiments, the controller 110 is configured to track different operating parameters of the device 100, such as number of uses, time of use, ultrasound energy parameters and heater parameters. The controller 110 may store these different operating parameters in local memory on the device 100.

[00154] In some embodiments, the controller 110 may be configured to transmit the data to users, sellers, distributors and/or manufacturers of the device 100 to facilitate proper use of the device 100 or track the operating state of the device 100.

[00155] II. Topical Formulations

[00156] The device/topical combination can be chosen to enhance loading of ingredients into the stratum corneum so that further, natural diffusion kinetics can occur and the selected ingredients can take effect. Designed formulated products, as described in embodiments herein, coupled to topical application of an electronic device, used as instructed, will modulate skin's natural barrier properties and provide for penetration of a desired ingredient into the upper layers of the skin. We have now discovered that topical compositions, including those in the form of an emulsion, gel serum or viscous solution, can be delivered more effectively with one or more of the embodiments of the device described herein to effect ingredient delivery to a targeted part of human skin such as to, into, or through the stratum corneum.

[00157] The aforementioned topical formulations may comprise a carrier and/or a selected agent. In an embodiment, the aforementioned topical formulations may comprise more than one carrier and/or more than one selected agent.

[00158] The carrier composition or selected agent may include any known cosmetic agent or any of active pharmaceutical ingredient or combination of active ingredients known in the art. Cosmetics and active ingredients for use with the devices and methods described here may include those active ingredients that are known to those of ordinary skill in the art, such as those described in: Draelos, Z. D., Active agents in skin care products, *Plast. Reconstru. Surg.*, 2010, *125,* 719-724. A topical formulation may include one or more hydrophobic (i.e. oil-soluble) or hydrophilic (i.e. water-soluble) active ingredients that are known to those of ordinary skill in the art, and may be in the form of a lotion, foam, or cream. Any pharmaceutical ingredient or combination thereof suitable for topical or transdermal delivery may be used with the devices and methods disclosed herein.

[00159] The methods described herein are useful and effective for skin care, for the treatment of a variety of skin conditions and disorders, and for drug delivery for other conditions and disorders. For example, the methods may be used to improve skin hydration, improve skin firmness, improve skin elasticity, reduce the mean area of skin wrinkles, reduce pore size, improve skin clarity, and reduce skin blotchiness, or give the cosmetic impression of any of the foregoing. In an embodiment, a product composition described herein is used for treating a skin condition or disorder. In an embodiment, a method of treating a skin condition or disorder using a product composition described herein comprises the step of administering the composition to a subject. In an embodiment, a method of treating a skin condition or disorder using a product composition described herein comprises the step of topically administering the composition. In an embodiment, a method of treating a skin condition or disorder using a product composition described herein comprises the step of topically administering the composition to the facial skin of a human subject.

[00160] The skin conditions that may be treated or cosmetically addressed by the devices and methods include, but are not limited to, dry skin, eczema, skin discoloration, ashen skin, acne, acne vulgaris, skin blemishes, skin discoloration, skin wrinkles, psoriasis, diaper rash, sun burn, seborrhea, atopic dermatitis, lichen simplex chronicus, poison ivy, inflammatory pruritus, photo-aging, smoker's lines, thin skin, elastosis, freckles, solar lentigo, guttate hypomelanosis, ideopathic guttate hypomelanosis, white marks, telangiectases, cherry angiomas, senile purpura, solar comedones, colloid milia, and seborrhoeic keratoses. Various skin conditions that may be treated, prevented, or cosmetically addressed using the devices and methods described herein are also

described in U.S. Patent Publication Nos. 2002/0004056 A1, 2004/0156805, 2006/0257845, and 2013/0210759, the disclosure of which is incorporated herein by reference.

[00161] The devices and methods described herein are also effective in the topical delivery of active ingredients, including cosmetic ingredients, ingredients that improve the appearance of skin, pharmaceutical active ingredients used to treat or prevent a disorder or condition, and ingredients used to improve consumer perception of a product. In an embodiment, a method of treating a disease or illness in a mammal includes the step of delivering a pharmaceutical active ingredient using a device or method described herein. In an embodiment, a method of improving the appearance of skin includes the step of delivering a cosmetic ingredient using a device or method described herein. In an embodiment, a method of improving the consumer perception of a product includes the step of delivering a cosmetic ingredient using a device or method described herein.

[00162] III. Assay Test Methodology

[00163] Principle of the test

[00164] The test substance is applied to the surface of a synthetic skin sample separating the two chambers of a diffusion cell. The chemical remains on the synthetic skin for a specified time under specified conditions. The receptor fluid is sampled at time points throughout the experiment and analysed for the test chemical or ingredient.

[00165] Description of the method

[00166] Diffusion Cell - A diffusion cell consists of a donor chamber and a receptor chamber between which the skin is positioned (an example of a typical design is provided in Figure 1). The cell should provide a good seal around the synthetic skin, enable easy sampling and good mixing of the receptor solution in contact with the underside of the synthetic skin, and good temperature control of the cell and its contents. Static and flow-through diffusion cells are both acceptable. Normally, donor chambers are left unoccluded during exposure to a finite dose of a test preparation. However, for infinite applications and certain scenarios for finite doses, the donor chambers may be occluded.

[00167] Receptor Fluid - The use of a physiologically conducive receptor fluid is preferred although others may also be used provided that they are justified. The precise composition of the receptor fluid should be provided. Adequate solubility of the test chemical in the receptor fluid should be demonstrated so that it does not act as a barrier to absorption. In addition, the receptor fluid should not affect skin preparation integrity. In a flow-through system, the rate of flow must not hinder diffusion of a test substance into the receptor fluid. In a static cell system, the fluid should be

continuously stirred and sampled regularly. If metabolism is being studied, the receptor fluid must support skin viability throughout the experiment.

[00168] Types of Skin Preparations -

[00169] A) Human skin - It is recognised that the use of human skin is subject to national and international ethical considerations and conditions. Although viable skin is preferred, non-viable skin can also be used provided that the integrity of the skin can be demonstrated. Either epidermal membranes (enzymically, heat or chemically separated) or split thickness skin (typically 200-400 µm thick) prepared with a dermatome, are acceptable. Full thickness skin may be used but excessive thickness (. > 1 mm) should be avoided unless specifically required for determination of the test chemical in layers of the skin. The selection of species, anatomical site and preparative technique must be justified. Acceptable data from a minimum of four replicates per test preparation are required. In this study we have decided to focus on other skin preparations such synthetic skin membranes because human skin may harbor pathogenic viruses, and may be inconsistent with respect to results.

[00170] B) Human Reconstructed Epidermal Skin Model - Standardized Cultured skin models from sources like MatTek corporation can be used for this test. This model provides a consistent source of standardized thickness and dimensions that can be used up to 22 mm in diameter (Epiderm Normal Human 3D Epidermis EPI-606).

[00171] C) Skin Model Membranes (Strat M-Membranes) - A consistent and stable synthetic non-animal based model for transdermal diffusion which is predictive of diffusion of human skin. This model has been demonstrated to strongly correlate to cadaver human skin behavior. It is an appropriate model for screening compounds with diverse physiochemical properties. This model will be the first line of experimentation for diffusion testing. This is the type chosen for this experiment.

[00172] Skin Preparation Integrity - It is essential that the skin is properly prepared. Inappropriate handling may result in damage. Hence the integrity of the prepared skin must be checked. As a general guidance, freshly excised skin should be used within 24 hrs. When skin preparations have been stored prior to use, evidence should be presented to show that barrier function is maintained.

[00173] Test Substance - The test substance is the entity whose diffusion characteristics are to be studied. The compounds being studied must each have a developed method of analysis by analytical instrumentation.

[00174] **Test Preparation** - The test substance preparation (e.g., neat, diluted or formulated material containing the test substance which is applied to the skin/ membrane) should be the same (or a realistic surrogate) as that to which humans or other potential target species may be exposed. Any variation from the 'in-use' preparation must be justified.

[00175] **Test Substance formulations and concentrations** - Normally more than one concentration of the test substance is used in typical formulations, spanning the realistic range of potential human exposures. Likewise, testing a range of typical formulations should be considered. In this study we will test the diffusion of actives with a 1% concentration for active ingredients, and also several formulations with similar concentrations of three actives; Ascorbic acid, Tetrahexyldecyl Ascobate, and Acetyltetrapeptide.

[00176] **Application to the skin** - Under normal conditions of human exposure to chemicals, finite doses are usually encountered. Therefore, an application that mimics human exposure should be used. The quantity should be justified by the expected use conditions, the study objectives or physical characteristics of the test preparation.

[00177] **Temperature** - The passive diffusion of chemicals (and therefore their skin absorption) is affected by temperature. The diffusion chamber and skin should be maintained at a constant temperature close to normal skin temperature of 32 1°C. Different cell designs will require different water bath or heated block temperatures to ensure that the receptor/skin is at its physiological norm. Humidity should preferably be between 30 and 70%. The experimental setup will be done in an incubator in order to equilibrate temperature and ensure lowest variability and temperature gradients.

[00178] **Duration of exposure and sampling** - Skin / Membrane exposure to the test preparation may be for the entire duration of the experiment or for shorter times (i.e., to mimic a specific type of human exposure). A period of sampling up to 24 hours is normally required to allow for adequate characterization of the absorption profile. For test substances that penetrate the skin rapidly this may not be necessary and may require only up to 6 hours, but, for test substances that penetrate slowly, longer times may be required. Sampling frequency of the receptor fluid should allow the absorption profile of the test substance to be presented graphically.

[00179] **Terminal Procedures** - All components of the test system should be analysed and recovery is to be determined. This includes the donor chamber, the skin surface, the skin preparation and the receptor fluid/chamber. In some cases, the skin may be fractionated into the exposed area of skin and area of skin under the cell flange, and into, epidermis and dermis fractions, for separate analysis.

[00180] **Analysis** - In all studies adequate recovery should be achieved. The amount of test substance in the receptor fluid, skin preparation, skin / membrane surface and apparatus should be analysed, using a suitable technique. All trials will be done in duplicate. Ten (10) pull points will be analysed per cycle.

[00181] **Method of analysis** - Solubility/ UPLC/ HPLC/ UVvis spectroscopic method development - working with three actives:

[00182] **Ascorbic Acid** - water soluble active - can use regular buffer. Determine HPLC conditions and UV/VIS spectroscopic detection, and column type, detector type, detection parameters and limits with internal standard (caffeine).

[00183] **Tetrahexyldecyl Ascorbate** - Oil soluble - may need to adjust the buffer in order to assure that it is soluble at all times. The Tetrahexyldecyl Ascorbate must not migrate or adhere to packaging like glass vials upon packaging and transport. The Tetrahexyldecyl Ascorbate must not separate and migrate and float to top of buffer solution upon 48 hrs standing (concentration must be static and uniform from T0 to 48 hrs). Determine HPLC conditions, detector type, detection parameters and limits with internal standard (caffeine). Solubilizers such as Albumin, Peg-40 hydrogenated castor oil, or other ethoxylated or pegylated emulsifiers will be tried for these studies. Must conduct stability study with mixed active/ buffer solution/ emulsifier to determine if stable after 48 hours.

[00184] **Acetyltetrapeptide** - water soluble - may need to adjust buffer in order not to have interferences. Peptides possibly not be compatible with albumin. Determine HPLC conditions and column type, detector type, detection parameters and limits with internal standard (caffeine).

[00185] The receptor buffer needs to be optimal - the active ingredient must be completely soluble and stable in the presence of the active ingredient.

[00186] **Data & Reporting**

[00187] **Data** - The analysis of receptor fluid, the distribution of the test substance chemical in the test system and the absorption profile with time, should be presented. Optionally, when finite dose conditions of exposure are used, the quantity washed from the skin or membrane, the quantity associated with the skin or membrane (and in the different skin layers if analyzed) and the amount present in the receptor fluid (rate, and amount or percentage of applied dose) should be calculated. Skin absorption may sometimes be expressed using receptor fluid data alone. However, when the test substance remains in the skin at the end of the study, it may need to be included in the total amount absorbed. When infinite dose conditions of exposure are used the data may permit the

calculation of a permeability constant (Kp). Under the latter conditions, the percentage absorbed is not relevant.

[00188] Methods to assess the rate, extent, and effectiveness of skin permeation using the device, formulations and methods of the invention will be apparent to one of skill in the art. For example, component(s) of the topical can be labeled with a detectable agent and permeation can be assessed by assaying tissue obtained from, e.g., stratum corneum stripping, punch biopsy or planed skin sample. Alternatively, HPLC or similar well-known methods can be used to identify and quantify topical ingredients that have permeated tissue samples or crossed membrane/skin delimited assay chambers. For evaluation of skin volume, plumpness, smoothness and related measures, assays such as weight and/or volume of defined skin samples can be evaluated; microscopic or macroscopic visual evaluation can be performed, or any other method known in the art.

[00189] IV. Method of Use

[00190] Figure 6 is a flow chart illustrating a method for using the device 100 to treat the skin of the user according to at least one embodiment. It is understood that the exemplary method is one of many alternative sequences of steps, or algorithms, which may be employed to enhance the deposition of topicals into the skin, and the components used may be any known in the art.

[00191] In some embodiments, at step 601, the user charges the device 100. For example, the user may insert an electrical end of cord into a wall charger, for example a USB cord and charger. Next, the user inserts a connector of the charging cord (e.g., a micro-USB) into the device 100. After charging is complete, the user unplugs the micro-USB connector from the device 100. In some embodiments, the device 100 includes light emitting diode (LED) light indicators that emit light during a charging cycle. In some embodiments, the device 100 may charge for 4 hours. In some embodiments, a charging LED remains steady on when fully charged and connected. In some embodiments, the device 100 requires recharging approximately every 30-60 uses.

[00192] In some embodiments, at step 602, the user applies a small amount of topical to the applicator tip 105 or the skin of the user.

[00193] In some embodiments, at step 603, the user turns on the device 100. For example, the user may press a power button to turn on the device 100.

[00194] In some embodiments, at step 604, the user selects the program setting. In one embodiment, if this is the first time the device 100 is turned on, the device 100 will default to the pre-programmed level 1 setting (e.g., constant tip temperature of 32 degrees Celsius). The user may change the level setting by pressing a level-selection button on the device 100 to cycle through the different level options. In some embodiments, upon subsequent use, device 100 will default to its

previous selected setting. In some embodiments, hidden LEDs appear over level-selection button. In some embodiments, one LED indicates level 1 is selected, two LEDs indicate level 2 is selected and three LEDs indicate that level 3 is selected. In some embodiments, the user selects the program settings using the same hand that is holding the device 100.

[00195] In some embodiments, at step 605, the user treats the skin. In some embodiments, the device 100 remains on for one minute, then shuts off. In some embodiments, the device 100 may provide haptic feedback (e.g., vibrate). In some embodiments, because the generation of ultrasound from the device 100 produces no audible sound or physical sensation, haptic feedback may be employed to alert the user that ultrasound is being generated. In these embodiments, when the device 100 is turned on, the user will feel a mild vibration within the device 100. This vibration may be temporally concurrent with the ultrasound output. Alternatively, the vibration may be cycled on and off (for example, a 0.3 second duration every 2.0 seconds) while the device 100 is generating ultrasound.

[00196] In some embodiments, the device 100 may include a small vibration motor that provides continuous or pulsed (e.g. for 0.5 seconds every 5 seconds) haptic feedback to indicate that the device 100 is emitting ultrasound energy and/or heat. The device 100 is also configured to provide haptic feedback in other scenarios, including: i) selected level of ultrasound energy and/or heat; ii) when the device 100 initiates providing ultrasound energy or heat, when the device 100 finishes providing ultrasound energy or heat, and/or iv) during a time duration indicating a preferred amount of time for providing ultrasound energy and/or heat to maximize the effectiveness of the device.

[00197] In some embodiments, at step 606, the user cleans the device. In some embodiments, the user wipes the device 100 clean with facial tissue. In some embodiments, the user may lightly rinse the device 100 under hot water.

[00198] In some embodiments, there are methods for using different embodiments of the device 100 in conjunction with different topical formulations described herein. These methods may provide enhanced results compared to using either embodiments of the device 100 or the topical formulation separately. These methods can be tested using small human clinical studies.

[00199] In at least one embodiment, there is included one or more computers having one or more processors and memory (e.g., one or more nonvolatile storage devices). In some embodiments, memory or computer readable storage medium of memory stores programs, modules and data structures, or a subset thereof for a processor to control and run the various systems and methods disclosed herein. In one embodiment, a non-transitory computer readable storage medium having

stored thereon computer-executable instructions which, when executed by a processor, perform one or more of the methods disclosed herein.

[00200] It will be appreciated by those skilled in the art that changes could be made to the exemplary embodiments shown and described above without departing from the broad inventive concept thereof. It is understood, therefore, that this invention is not limited to the exemplary embodiments shown and described, but it is intended to cover modifications within the spirit and scope of the present invention as defined by the claims. For example, specific features of the exemplary embodiments may or may not be part of the claimed invention and features of the disclosed embodiments may be combined. The words "right", "left", "lower" and "upper" designate directions in the drawings to which reference is made. The words "inwardly" and "outwardly" refer to directions toward and away from, respectively, the geometric center of the relevant device. Unless specifically set forth herein, the terms "a", "an" and "the" are not limited to one element but instead should be read as meaning "at least one".

[00201] It is to be understood that at least some of the figures and descriptions of the invention have been simplified to focus on elements that are relevant for a clear understanding of the invention, while eliminating, for purposes of clarity, other elements that those of ordinary skill in the art will appreciate may also comprise a portion of the invention. However, because such elements are well known in the art, and because they do not necessarily facilitate a better understanding of the invention, a description of such elements is not provided herein.

[00202] Further, to the extent that the method does not rely on the particular order of steps set forth herein, the particular order of the steps should not be construed as limitation on the claims. The claims directed to the method of the present invention should not be limited to the performance of their steps in the order written, and one skilled in the art can readily appreciate that the steps may be varied and still remain within the spirit and scope of the present invention.

CLAIMS

What is claimed is:

1. A handheld skin care appliance comprising:

an ultrasound source;

at least one heat source separate from the ultrasound source;

an appliance tip coupled to the ultrasound source and coupled to the at least one heat source in a configuration to apply through the appliance tip ultrasound waves in a frequency range of about 100 kHz to about 1 MHz and heat at a temperature in a range of about 30°C to about 40°C.

2. A handheld skin care appliance comprising:

an ultrasound source comprising a piezoelectric transducer;

at least one heat source separate from the ultrasound source;

an appliance tip coupled to the ultrasound source and coupled to the at least one heat source; and

wherein the piezoelectric transducer and appliance tip are configured to produce an ultrasound field emitted from the appliance having a shape similar to the shape of the appliance tip.

3. A handheld skin care appliance comprising:

an ultrasound source comprising a piezoelectric transducer that produces both ultrasound and heat;

at least one heat source separate from the piezoelectric transducer;

an appliance tip coupled to the ultrasound source and coupled to the at least one heat source; and

a microcontroller configured to adjust electrical power to the heat source to maintain the appliance tip at a set temperature while minimizing the electrical power to said heat source.

4. The skin care appliance of claim 1 wherein the ultrasound source is configured to deliver a peak power level and an average power level to achieve a Mechanical Index of less than 0.5 and a Thermal Index Cranium of less than 2.0.

5. The skin care appliance of claim 1 wherein the appliance tip is coupled to the ultrasound source in a configuration that delivers ultrasound waves through the appliance tip at a level in the range of about 200 kHz to about 500 kHz.

6. The skin care appliance of claim 4 wherein the peak power level is less than 2 watts and the average power level is less than 250 milliwatts.

7. The skin care appliance of claim 1 wherein the at least one heat source comprises two heat sources disposed proximate to the appliance tip and wherein the appliance tip includes an aluminum output surface.

8. The skin care appliance of claim 7 wherein the aluminum output surface includes a texture configured to define a topical medicament reservoir and provide therapeutic benefit to the skin.

9. The skin care appliance of claim 1 further comprising:

control circuitry configured to activate the ultrasound source and the at least one heat source through states that includes one or more of: emitting ultrasound only, emitting ultrasound and heat simultaneously, emitting ultrasound followed by heat; and emitting heat followed by ultrasound.

10. The skin care appliance of claim 9 wherein the control circuitry is configured to vary a voltage applied to the ultrasound source to vary the ultrasound waves emitted from the ultrasound source.

11. The skin care appliance of claim 9 wherein the control circuitry is configured to vary a duty cycle of the voltage applied to the ultrasound source to vary the ultrasound waves emitted from the ultrasound source.

12. The skin care appliance of claim 9 wherein the control circuitry is configured to detect a resonant frequency of the ultrasound source and vary at least one of: a voltage and a duty cycle applied to the ultrasound source.

13. The skin care appliance of claim 9 wherein the control circuitry is configured to detect a load impedance of the ultrasound source and vary at least one of: a voltage and a duty cycle applied to the ultrasound source.

14. The skin care appliance of claim 9 wherein the control circuitry is configured to store usage information of the skin care appliance.

15. The skin care appliance of claim 9 wherein the control circuitry is configured to transmit usage information of the skin care appliance.

16. The skin care appliance of claim 1 wherein the temperature of said appliance tip may be adjusted while the appliance tip is contacting the skin of a user.

17. The skin care appliance of claim 16, wherein said temperature adjustment is made by the user holding the skin care appliance using a hand that is holding the skin care appliance.

18. The skin care appliance of claim 1 wherein the ultrasound source is configured to deliver a peak power level and an average power level to achieve an output Mechanical Index (MI) of less than 0.23 and a Thermal Index Cranium (TIC) of less than 1.0.

19. The skin care appliance of claim 1 wherein the ultrasound source delivers ultrasound waves at a frequency in the range of about 100 kHz but less than 1 MHz.

20. The skin care appliance of claim 1 wherein the appliance tip has a teardrop shape that causes a circular pattern of ultrasound waves emitted from the ultrasound source to have a non-circular shape after passing through the appliance tip.

21. The skin care appliance of claim 1 wherein the appliance tip has a non-circular shape.

22. The skin care appliance of claim 1 wherein the appliance tip has at least one of: grooves, chevrons and surface features.

23. The skin care appliance of claim 1 wherein the skin care appliance weighs less than 7 ounces.

24. The skin care appliance of claim 1, further comprising:

a temperature sensor coupled to the appliance tip to measure a temperature of an output surface of the appliance tip, and control circuitry configured to cause the heat source to emit a selected amount of heat based on the measured temperature.

25. The skin care appliance of claims 1, further comprising:

a haptic feedback device configured to provide haptic feedback when ultrasound waves are applied through the appliance tip.

26. The skin care appliance of claim 25, wherein said haptic feedback is provided for at least one of the following events: toggling ultrasound on or off; toggling heat on or off; selecting a level of ultrasound or heat; initiating applying ultrasound or heat, completing applying ultrasound or heat, expiration of a selected time duration of ultrasound or heat.

27. The skin care appliance of claim 1, wherein the ultrasound source is a single disk-type piezoelectric transducer.

28. The skin care appliance of claim 1, wherein the ultrasound source is a ring-shaped piezoelectric transducer.

29. The skin care appliance of claim 1, further comprising: a battery power source coupled to the ultrasound source and the at least one heat source and configured to power the ultrasound source, the at least one heat source and control circuitry.

30. A method of permeating skin with a selected agent comprising:

applying a topical formulation to a portion of an outer layer of skin, wherein the topical formulation includes the selected agent;

applying ultrasound to the portion of the outer layer of skin at a frequency in the range of about 100 kHz to about 1 MHz from an ultrasound source; and

applying heat to the portion of the outer layer of skin within a temperature range of about 30°C to about 40°C.

31. A method of treating skin using a handheld skin care appliance, comprising:

applying ultrasound to the skin using an ultrasound source comprising a piezoelectric transducer and an appliance tip, the appliance tip being coupled to the ultrasound source;

applying heat to the skin using at least one heat source separate from the ultrasound source and the appliance tip, the appliance tip being coupled to the at least one heat source;

producing a teardrop-shaped ultrasound field emitted from the appliance using the piezoelectric transducer having a circular shape and the appliance tip having a teardrop shape.

32. A method of treating skin using a handheld skin care appliance comprising:

applying ultrasound and heat to the skin using an ultrasound source comprising i) a piezoelectric transducer that produces both ultrasound and heat and ii) an appliance tip coupled to the ultrasound source;

applying heat using i) at least one heat source separate from the piezoelectric transducer and ii) the appliance tip coupled to the at least one heat source; and

adjusting electrical power to the heat source to maintain the appliance tip at a set temperature while minimizing the electrical power to said heat source using a microcontroller.

33. The method of claim 30 wherein applying ultrasound further comprises delivering a peak power level and an average power level to achieve a Mechanical Index of less than 0.5 and a Thermal Index Cranium of less than 2.0.

34. The method of claim 30 wherein the selected agent includes molecules that penetrate the skin in response to the application of ultrasound and heat to the portion of the outer layer of skin.

35. The method of claim 30 wherein the selected agent permeates the skin to a greater degree relative to the permeation obtained using an otherwise identical method that does not include the steps of applying ultrasound and applying heat.

36. The method of claim 30, wherein the selected agent permeates the skin to a greater degree when compared to the permeation of the selected agent when a higher frequency ultrasound

application is employed in a method that is otherwise substantially identical to the method of claim 28.

37. The method of claim 30 wherein the topical formulation comprises a selected agent having a molecular weight of at least 200 Daltons.

38. The method of claim 30 wherein a penetration of the selected agent is through at least 50% of a stratum corneum.

39. The method of claim 30 wherein the heat and ultrasound are applied according to one or more of: i) simultaneously, ii) heat followed by ultrasound; iii) ultrasound followed by heat; iv) prior to application of the topical formulation; v) after application of topical formulation; vi) application of topical between the application of heat and application of ultrasound, and vii) alternating between application of heat for approximately 30 seconds, followed by application of ultrasound for 30 seconds.

40. The method of claim 30, wherein the selected agent comprises lipophilic ingredients.

41. The method of claim 30, wherein the selected agent comprises hydrophilic ingredients.

42. The method of claim 30, wherein the selected agent comprises skin protectants.

43. The method of claim 30, wherein the selected agent comprises pharmacologically active ingredients.

44. The method of claim 30, wherein the selected agent comprises antibacterial and antifungal agents.

45. The method of claim 30, wherein the topical formulation is formulated to improve penetration of the selected agent into the skin when applying ultrasound or heat relative to penetration of the selected agent without applying ultrasound or heat.

46. The method of claim 30, wherein the ultrasound is applied by an ultrasound source of a skin care appliance.

47. The method of claim 46, wherein the heat is applied by a heat source of the skin care appliance.

48. The method of claim 47, wherein control circuitry of the skin care appliance is configured to cause the ultrasound source to apply the ultrasound and the heat source to apply the heat.

49. The method of claim 48, wherein the control circuitry varies a voltage applied to the ultrasound source to vary the ultrasound produced by the ultrasound source.

50. The method of claim 48, wherein the control circuitry varies a duty cycle of the voltage applied to the ultrasound source to vary the ultrasound produced by the ultrasound source.

51. The method of claim 48, wherein the control circuitry is configured to detect a resonant frequency of the ultrasound source and vary at least one of: a voltage and a duty cycle applied to the ultrasound source.

52. The method of claim 48, wherein the control circuitry is configured to detect a load impedance of the ultrasound source and vary at least one of: a voltage and a duty cycle applied to the ultrasound source.

53. The method of claim 48, wherein the control circuitry is configured to store usage information of the skin care appliance.

54. The method of claim 48, wherein the control circuitry is configured to transmit usage information of the skin care appliance.

55. The method of claim 30, further comprising adjusting the temperature within the temperature range while an appliance tip of a skin care appliance is contacting the skin of a user.

56. The method of claim 55, wherein the user holding a skin care appliance applying the ultrasound and the heat adjusts the temperature using a hand that is holding the skin care appliance.

57. The method of claim 30, wherein a skin care appliance applies the ultrasound and is configured to deliver a peak power level and an average power level to achieve an output Mechanical Index (MI) of less than 0.23 and a Thermal Index Cranium (TIC) of less than 1.0.

58. The method of claim 31, wherein a frequency of the ultrasound is in a range of about 100 kHz to about 1 MHz.

59. The method of claim 30 wherein a profile of the ultrasound has a teardrop shape.

60. The method of claim 31, further comprising:
measuring the temperature of an output surface of the appliance tip and adjusting the heat applied to the skin based on the measured temperature.

61. The method of claim 30, further comprising:
providing haptic feedback to a user when applying the ultrasound.

62. The method of claim 61, wherein said haptic feedback is provided for at least one of the following events: toggling ultrasound on or off; toggling heat on or off; selecting a level of ultrasound or heat; initiating applying ultrasound or heat, completing applying ultrasound or heat, expiration of a selected time duration of ultrasound or heat.

63. The method of claim 30, wherein delivery of the selected agent into the skin increases by 25, 50, 100, 150, 200, 250, 280 or 300% compared to application of selected agent alone to the skin, as measured by rate, volume, or concentration

64. The method of claim 30, wherein the topical formulation is in a form selected from the group consisting of a cream, liquid, serum, gel, stick, impregnated fabric, and powder.

65. The method of claim 30, wherein the topical formulation has a viscosity of one of: 10,000 cps to 1,000,000 cps; 50,000 cps to 500,000 cps; and 100,000 cps to 200,000 cps.

66. The method of claim 30, wherein the selected agent is a cosmetic.

67. The method of claim 30, wherein the topical formulation is selected from the group consisting of: a water soluble topical formulation and a lipid soluble topical formulation.

68. The method of claim 30, wherein the selected agent is a medicament that is configured to cross into a bloodstream of the user.

69. The method of claim 30, wherein the topical formulation is a fabric impregnated with a surfactant or surfactant mixture so as to impart cleansing and exfoliation properties.

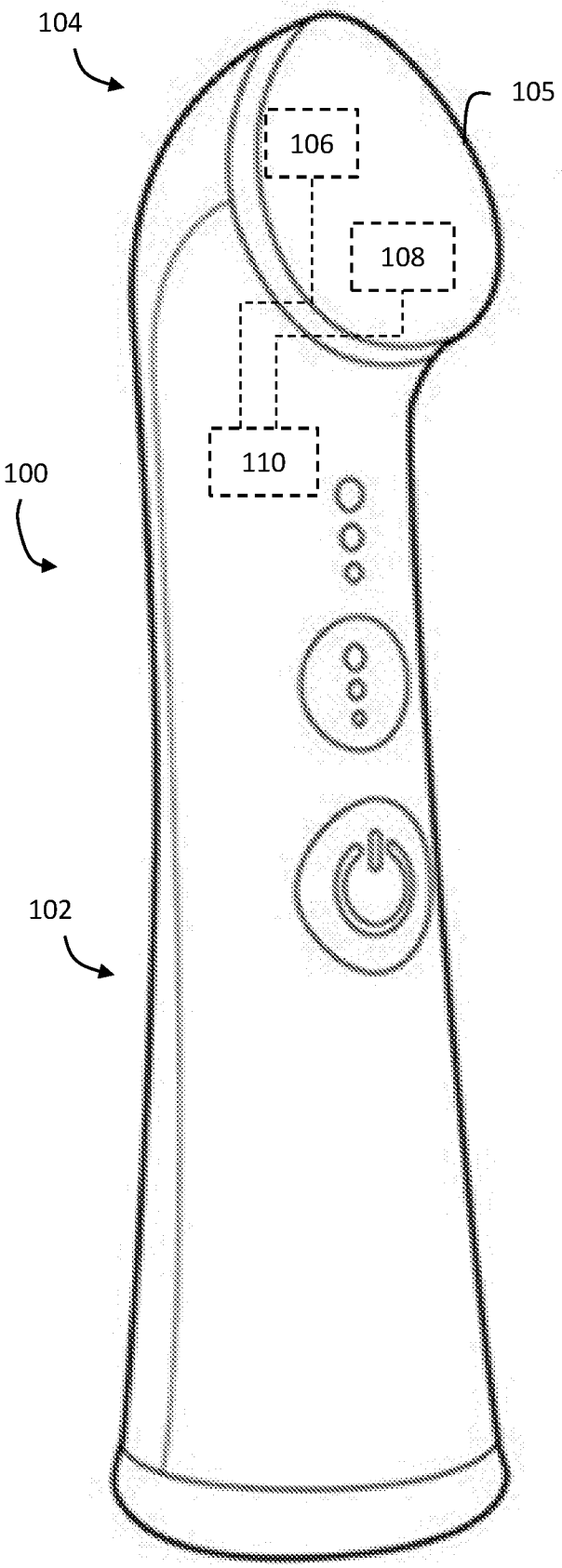


Fig. 1

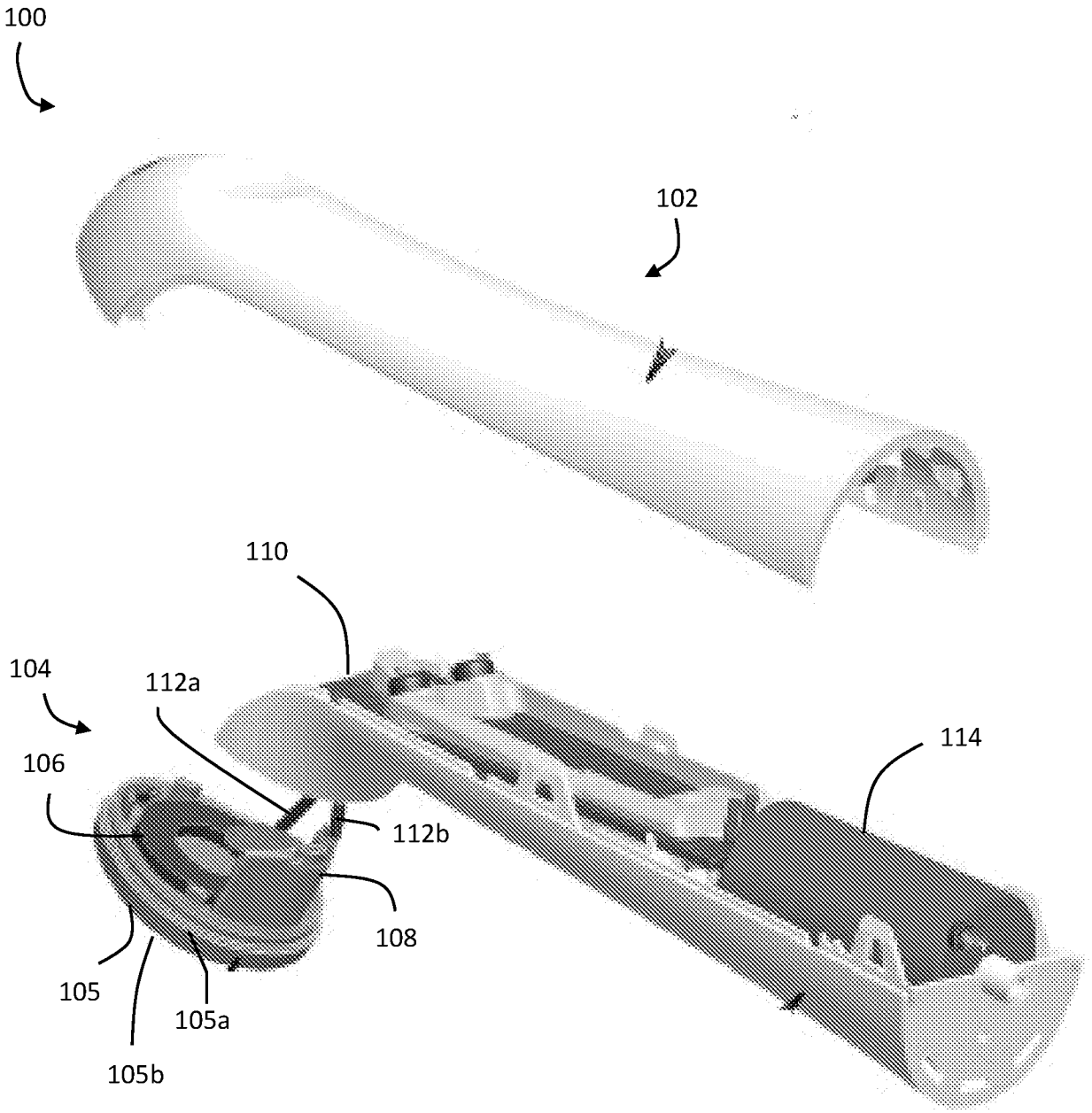


Fig. 2

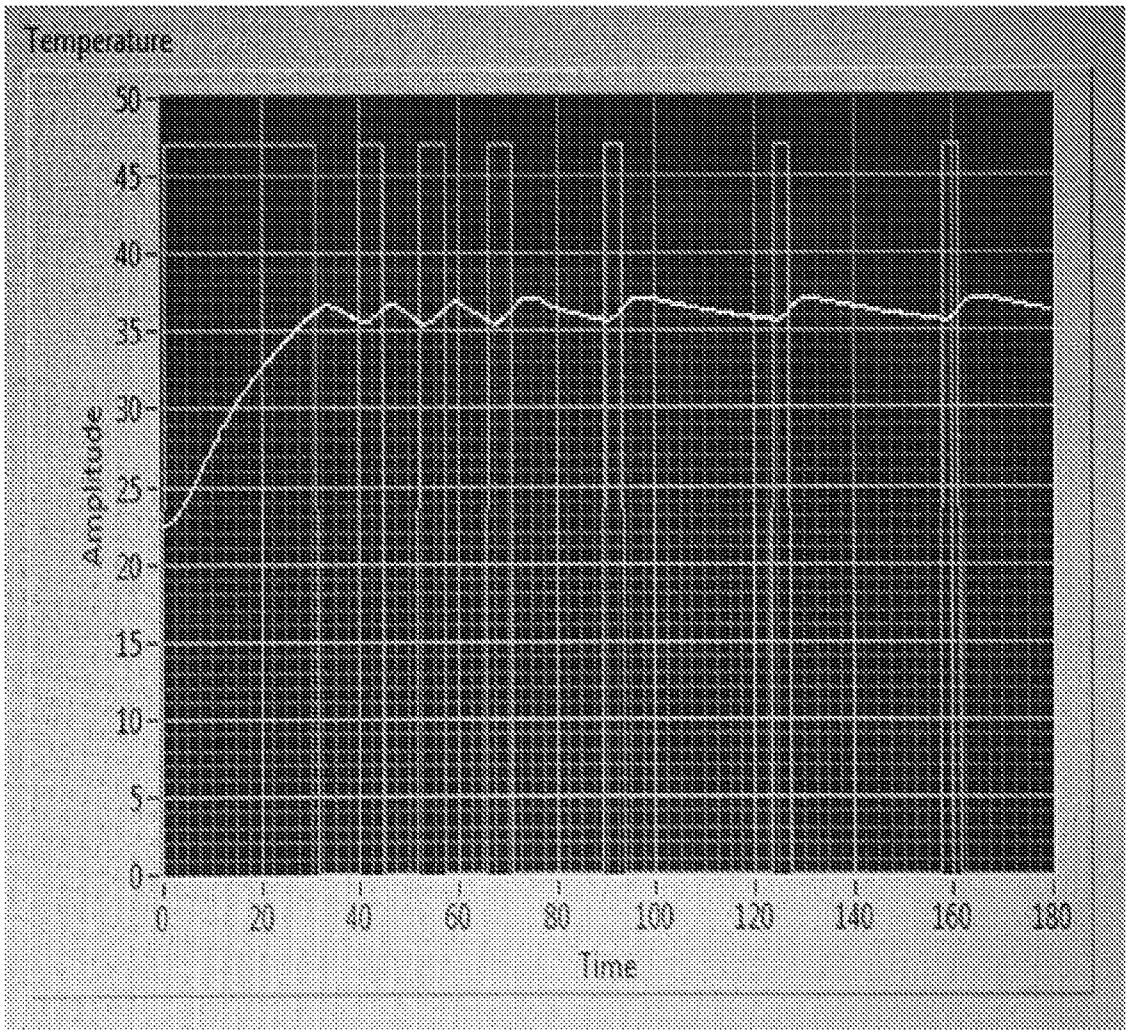

Temperature
Amplitude
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
Time

Fig. 3

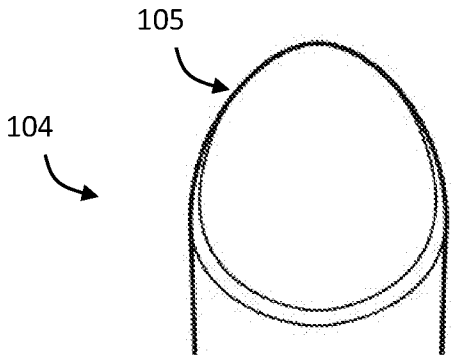


Fig. 4

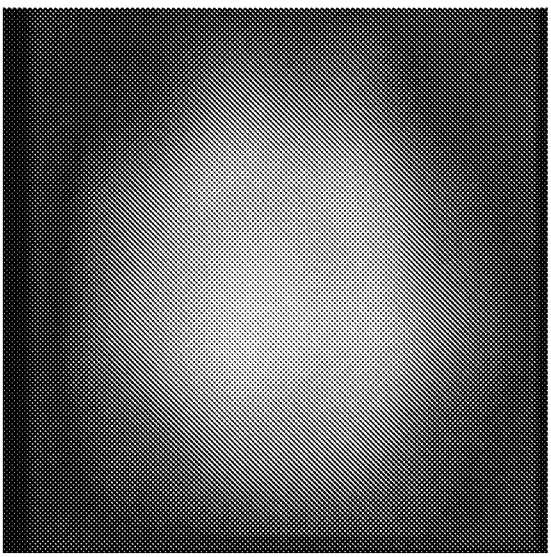


Fig. 5A

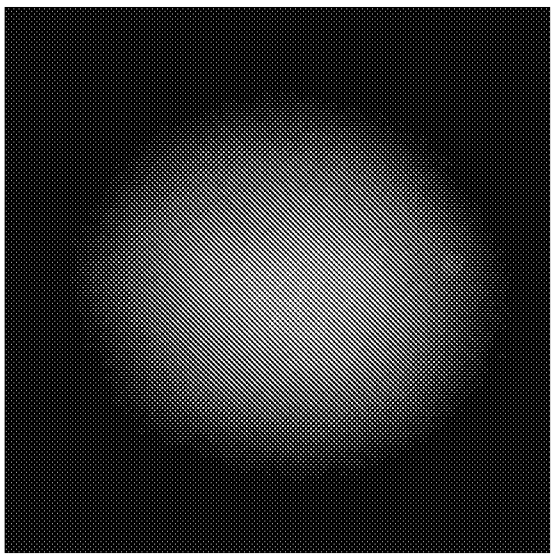


Fig. 5B

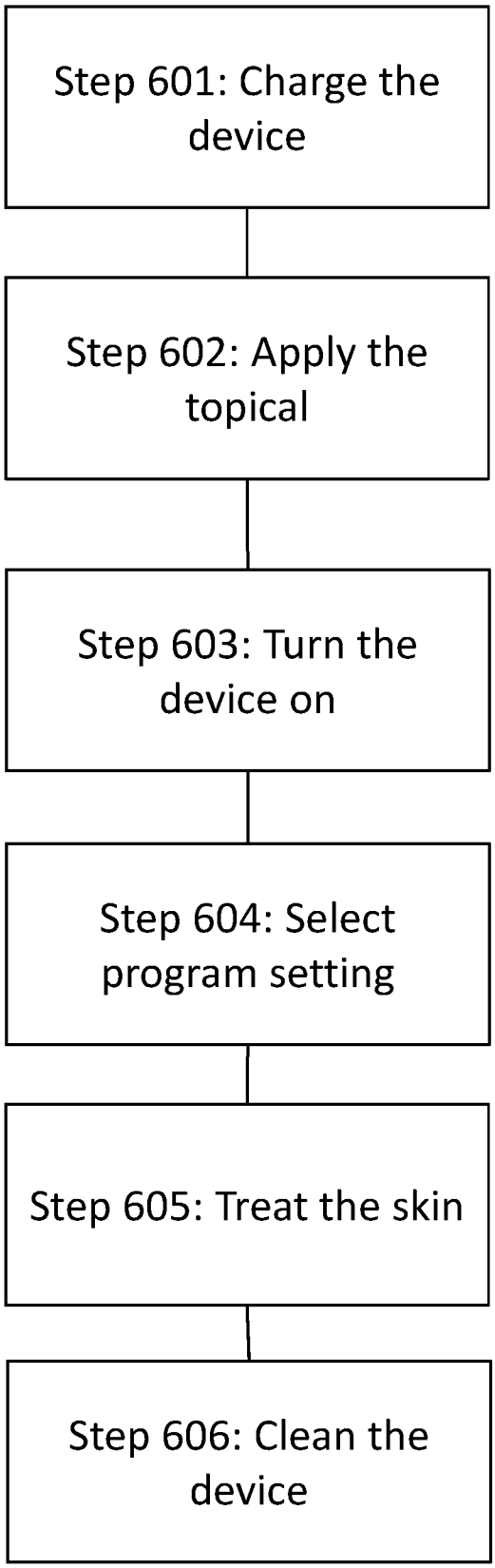

Step 601: Charge the device
Step 602: Apply the topical
Step 603: Turn the device on
Step 604: Select program setting
Step 605: Treat the skin
Step 606: Clean the device

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/014145

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See Extra Sheet(s)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1, 3-29, 32

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/014145

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61N 7/02; A61B 8/14; A61B 18/04; A61K 8/67; A61N 1/36; A61N 5/06 (2017.01)
CPC - A61N 5/0616; A61K 31/355; A61M 37/0092; A61N 1/36014; A61N 5/062; A61N 7/02 (2017.02)

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)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 601/3; 601/2; 604/2; 604/22; 606/27; 606/28; 607/3; 607/88 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/0276248 A1 (SONOVIA HOLDINGS LLC) 18 September 2014 (18.09.2014) entire document	1, 3-29, 32
A	US 2011/0112405 A1 (BARTHE et al) 12 May 2011 (12.05.2011) entire document	1, 3-29, 32
A	US 2008/0139974 A1 (DA SILVA) 12 June 2008 (12.06.2008) entire document	1, 3-29, 32

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 May 2017	24 MAY 2017
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571 272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/014145

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I, claims 1, 3-29, 32 are drawn to a method of controlling a skin care appliance.
Group II, claims 2, 30-31, 33-69 are drawn to a method including applying a topical formulation to skin.

The inventions listed in Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, an appliance tip coupled to the ultrasound source and coupled to the at least one heat source in a configuration to apply through the appliance tip ultrasound waves, a microcontroller configured to adjust electrical power to the heat source to maintain the appliance tip at a set temperature while minimizing the electrical power to said heat source, adjusting electrical power to the heat source to maintain the appliance tip at a set temperature while minimizing the electrical power to said heat source using a microcontroller, are not present in Group II; and the special technical features of Group II, wherein the piezoelectric transducer and appliance tip are configured to produce an ultrasound field emitted from the appliance having a shape similar to the shape of the appliance tip, applying a topical formulation to a portion of an outer layer of skin, wherein the topical formulation includes the selected agent, producing a teardrop-shaped ultrasound field emitted from the appliance using the piezoelectric transducer having a circular shape and the appliance tip having a teardrop shape, are not present in Group I.

Groups I and II share the technical features of a method comprising applying ultrasound to a portion of an outer layer of skin at a frequency in the range of about 100 kHz to about 1 MHz from an ultrasound source; and applying heat to the portion of the outer layer of skin within a temperature range of about 30 C to about 40 C. However, these shared technical features do not represent a contribution over the prior art. Specifically, US 2014/0276248 A1 to Sonovia Holdings LLC teaches of a method (Abstract) comprising applying ultrasound to a portion of an outer layer of skin (Fig. 9, wherein ultrasound emitter 630 applies ultrasound to a skin surface, para. [0205]-[0206]) at a frequency in the range of about 100 kHz to about 1 MHz from an ultrasound source (Fig. 9, wherein the ultrasound emitter 630 applies energy at between 100 kHz and 1 MHz, para. [0085]); and applying heat to the portion of the outer layer of skin (Fig. 9, wherein graphene layer 620a acts as a heater layer to heat the skin, para. [0206]; wherein the graphene acts to heat tissue by passing a current therein, thereby resistively heating the layer, para. [0179] & [0176]) within a temperature range of about 30 C to about 40 C (Para. [0187], wherein the skin is heated to between 38 to 41 degrees Celsius).

Since none of the special technical features of the Group I and II inventions are found in more than one of the inventions, unity is lacking.