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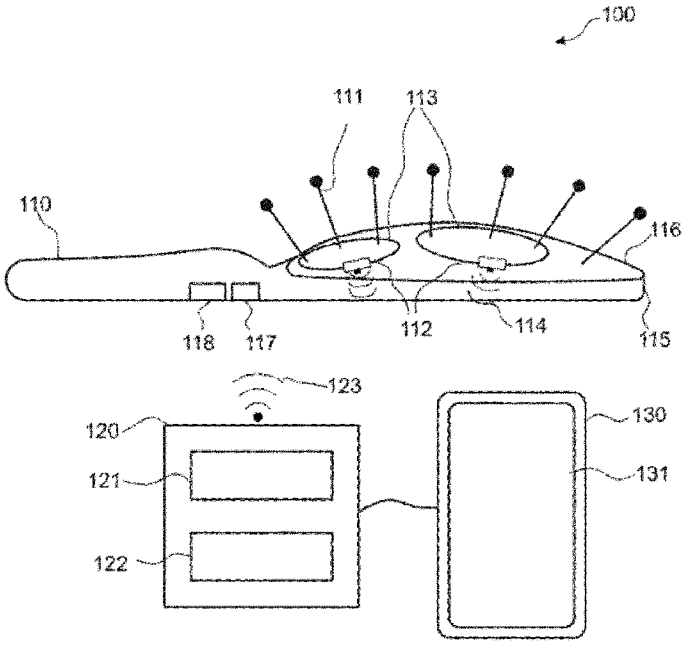

Fig. 1

(57) Abstract: Disclosed are methods, apparatuses, systems A method for generating formulation control data for producing a hair product for treating hair conditions. Further disclosed are hair products and hair formulations produced based on the generated formulation control data.

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METHOD FOR PROVIDING A HAIR PRODUCT

TECHNICAL FIELD

Disclosed are methods, apparatuses, computer elements, hair products or systems for generating formulation control data for producing or providing a hair product for treating one or more hair condition(s), wherein a hair property is provided by sensor means and formulation control data for providing or producing a hair product is derived. Further disclosed are hair products and hair formulations produced based on the generated formulation control data.

TECHNICAL BACKGROUND

Personalized hair treatment is an emerging field including the determination of conditions to be treated or the providing of treatment according to user's needs. US2020221854A1 discloses systems including a sensor for determining an item of hair condition information for a user. EP3668375A1 discloses a system for determining a hair condition. EP3681335A2 discloses a system with a reservoir that can hold, for example, components of shampoos, conditioners, deep conditioners or hair dyes. EP3692490A1 discloses a method for computer-assisted determination of a cosmetic product. EP3794611A1 discloses a processing unit that determines the surface properties of the hair based on the optical characteristics or images of hair.

SUMMARY OF THE INVENTION

In one aspect disclosed is a method, in particular a computer-implemented method, for generating formulation control data for providing or producing a hair product for treating one or more hair condition(s), the method comprising:

- providing a vibration signal measured by a hairbrush including bristles connected to one or more vibration sensor(s),
- detecting at least one hair property associated with the hair brushed by analyzing the vibration signal,
- generating formulation control data by deriving one or more formulation component(s) from the at least one detected hair property associated with the hair brushed,
- providing the formulation control data usable to provide or produce the hair product containing the one or more formulation component(s) to be used e.g. for treating one or more hair condition(s).

In another aspect disclosed is an apparatus for generating formulation control data for providing or producing a hair product for treating one or more hair condition(s), the method comprising:

- a hairbrush interface configured to provide a vibration signal measured by the hairbrush including bristles connected to one or more vibration sensor(s),
- a detector configured to detect at least one hair property associated with the hair brushed by analyzing the vibration signal,

- a generator configured to generate formulation control data by deriving one or more formulation component(s) from the at least one detected hair property associated with the hair brushed,
- a control data providing interface configured to provide the formulation control data usable to provide or produce the hair product containing the one or more formulation component(s) to be used e.g. for treating one or more hair condition(s).

In another aspect disclosed is a method for monitoring one or more hair condition(s), the apparatus comprising:

- providing at least one current vibration signal measured by a hairbrush including bristles connected to one or more vibration sensor(s) after treatment by the hair product provided based on the formulation control data generated according to the method(s) or apparatus(es) disclosed herein,
- providing at least one historical hair property detected in one or more historical vibration signal(s), wherein at least one historical vibration signal was used to generate formulation control data according to the method(s) or apparatus(es) disclosed herein,
- detecting at least one current hair property associated the hair brushed from the at least one current vibration signal,
- generating a difference between the at least one current hair property associated with the hair brushed from the current vibration signal and the at least one historical hair property determined from the one or more historical vibration signal(s),
- providing the generated difference for at least one current hair property associated with the hair brushed.

In another aspect disclosed is an apparatus for monitoring one or more hair condition(s), the apparatus comprising:

- a hairbrush interface configured to provide at least one current vibration signal measured by a hairbrush including bristles connected to one or more vibration sensor(s) after treatment by the hair product provided based on the formulation control data generated according to the method(s) or apparatus(es) disclosed herein,
- a historical data interface configured to provide at least one historical hair property detected in one or more historical vibration signal(s), wherein at least one historical vibration signal was used to generate formulation control data according to the method(s) or apparatus(es) disclosed herein,
- a detector configured to detect at least one current hair property associated with the hair brushed from the at least one current vibration signal,
- a generator configured to generate a difference between the at least one current hair property associated with the hair brushed from the current vibration signal and the at least one historical hair property determined from the one or more historical vibration signal(s),
- an output interface configured to provide the generated difference for at least one current hair property associated with the hair brushed.

In another aspect disclosed is a method for producing a hair product for treating one or more hair condition(s), the method comprising:

- providing formulation control data for producing the hair product as disclosed herein,
- producing the hair product according to the formulation control data.

In another aspect disclosed is an apparatus for producing a hair product for treating one or more hair condition(s), the apparatus comprising:

- a providing interface configured to provide formulation control data for producing the hair product as disclosed herein,
- a production apparatus configured to produce the hair product according to the formulation control data.

In another aspect disclosed is a system for producing a hair product, the system comprising an apparatus for generating formulation control data as disclosed herein and an apparatus for producing a hair product for treating hair conditions as disclosed herein, wherein the apparatus may be configured to mix formulation components.

In another aspect disclosed is the use of the formulation control data to produce a hair product for treating one or more hair condition(s).

In another aspect disclosed is a hair product for treating one or more hair condition(s) provided or produced based on or by using the formulation control data as generated according to the methods or by the apparatuses or systems disclosed herein.

In another aspect disclosed is a computer element, such as a computer readable storage medium, a computer program or a computer program product, comprising instructions, which when executed by a computing node or a computing system, direct the computing node or computing system to provide ingredients data associated with formulation components to provide or produce the hair product, wherein the ingredients data is used to generate control data according to the computer-implemented methods or by the apparatuses disclosed herein.

In another aspect disclosed is a system including:

- a computer element, such as a computer readable storage medium, a computer program or a computer program product, comprising instructions, which when executed by a computing node or a computing system, direct the computing node or computing system to generate formulation control data as disclosed herein and/or configured to provide ingredients data associated with formulation components usable to provide or produce the hair product, wherein the ingredients data is used to generate control data according to the computer-implemented methods or the apparatuses disclosed herein, and
- one or more capsule(s) each including one or more formulation component(s) usable to produce the hair product based on the ingredients data, wherein the capsule(s) may be configured to be inserted into or placed in one or more apparatus(es) for producing the hair product.

In another aspect disclosed is a computer element, such as a computer readable storage medium, a computer program or a computer program product, comprising instructions, which when executed by a computing node or a computing system, direct the computing node or computing system to carry out the steps of the computer-implemented methods disclosed herein or to provide the formulation control data generated according to the computer-implemented methods disclosed herein.

Any disclosure and embodiments described herein relate to the methods, the apparatuses, the systems, hair products, hair product ingredients, uses and/or the computer elements lined out above and below. Advantageously, the benefits provided by any of the embodiments and examples equally apply to all other embodiments and examples.

EMBODIMENTS

In the following, embodiments of the present disclosure will be outlined by ways of embodiments and/or example. It is to be understood that the present disclosure is not limited to said embodiments and/or examples.

Determining, generating includes initiating or causing to determine, generate. Providing includes "initiating or causing to access, determine, generate, send or receive". "Initiating or causing to perform an action" includes any processing signal that triggers a computing node to perform the respective action.

The methods, the systems, apparatuses, hair products, formulation control data and/or the computer elements disclosed herein enable personalized hair products tailored to the user's need. In particular, the composition of the hair product can be derived from hair diagnostics of the smart hairbrush with vibration sensors. This allows to tailor the hair product itself e.g. by tailoring the active ingredients to be added to a base formulation. For example, the base formulation or the active ingredients making-up the hair product can be adjusted depending on the hair property. This way hair can be treated in a more targeted manner. Moreover, the more efficient use of resources potentially combined with the use of natural material results in a positive environmental impact. In particular, the granularity of formulation components for generating control data allows for more tailoring of personalized hair products, if they are produced in a personalized manner. In addition to generating control data for pre-set hair product formulations and applying such pre-set hair product formulations, the generation of control data for producing the hair product based on formulation components allows for a higher degree of flexibility and scalability with a higher degree of customization.

The hair product may include any type of product suitable to treat hair. The hair product may include a care and/or styling product suitable to treat hair. The hair product for examples includes a shampoo, a conditioner, a deep conditioner, a hair mask, a hair serum, a hair spray, a hair styling product, a hair mist, a hair color product and/or a hair dye.

Formulation component(s) may include any ingredient(s) used to produce the hair product or contained in the hair product. The formulation component may include a base formulation or an active ingredient. The formulation components may make up the formulation of the hair product. The formulation component may include a base formulation to which one or more active ingredient(s) are to be added or are included according to the generated formulation control data. The base formulation may include one or more formulation ingredients. The formulation component may include one or more active ingredient(s) to be added to or included in the base formulation according to the formulation control data. The formulation components may relate to different sets of active ingredient(s), which may be comprised in the base formulation. The formulation component may relate to at least first active ingredient(s) included in base formulation. The formulation component may relate to at least second active ingredient(s) included in base formulation. The formulation components may be compatible to be added together according to the formulation control data. By generating formulation control data for formulation component(s), the flexibility in providing or producing the personalized hair product can be enhanced. Through generation of the formulation control data, the formulation component(s) making up the formulation of the personalized hair product can be adjusted and fine-tuned to the needs of the user.

The base formulation may include one or more formulation ingredients. The base formulation may refer to an ingredient combination suitable to be mixed with or including one or more active ingredient(s). The formulation ingredient, formulation component or active ingredient may be any cosmetically acceptable ingredient. These ingredients are known to the person skilled in the art and can be found in several publications, e. g. in the latest edition of the “International Cosmetic Ingredient Dictionary and Handbook” published by the Personal Care Products Council. Another well-known source of cosmetically acceptable ingredients is the cometic ingredient database CosIng. CosIng can be accessed via the internet pages of the European Commission.

In one embodiment the at least one active ingredient includes at least one of the following active ingredients:
oils such as almond oil or butters like shea butter, alcohols such as cetearyl alcohol, cetyl alcohol, stearyl alcohol, isopropyl alcohol, benzyl alcohol, alcohol denat or combinations thereof, tensides such as ammonium lauryl sulfate, sodium lauryl sulfate, sodium laureth sulfate, sodium myreth sulfate, sodium lauryl sulfoacetate, cocamidopropyl betaine, disodium cocoamphodiacetate disodium laureth sulfosuccinate, sodium coco sulfate or sodium C14-16 olefin sulfonate, glucosides such as lauryl glucoside, coco glucoside, decyl glucoside, disodium cocoyl glutamate, laurdimonium hydroxypropyl hydrolyzed wheat protein, lauryl glucoside, sodium cocoamphoacetate, sodium cocoyl glutamate, sodium cocoyl hydrolyzed wheat protein glutamate, sodium cocoyl hydrolyzed wheat protein, sodium cocoyl isethionate, sodium lauryl glucose carboxylate, sodium lauryl glucoside, sodium lauroamphoacetate cocamidopropyl hydroxysultaine or combinations thereof, active biogenic ingredients, UV light protection filters, insect repellents, antioxidants, film formers, sensory additives, effect pigments, pigments, whitening substances, tyrosine inhibitors (depigmenting agents), coolants, perfume oils, dyes, emollients, surfactants, emulsifiers, humectants, plant extracts, vitamins, peptides and panthenol.

The active ingredient may refer to an ingredient suitable to treat the hair condition detectable or detected via the vibration signal measured or associated with the hair condition detectable or detected via the vibration signal. The active ingredient allows to treat the hair condition and the methods disclosed herein allow for targeted use of active ingredients. By providing base formulation and/or active ingredients as formulation components, the hair formulation can be tailored to user's need.

The sensor may be configured to measure bristle vibrations when brushing the hair. The sensor may be configured to convert changes the bristles are exposed to into an electrical signal. The vibration sensor may include a sensor configured for acceleration measurement, such as a piezo-electric, piezo-resistive, resistive and/or conductive sensor. The vibration sensor may include a piezo based vibration sensor. The vibration signal may relate to movement of the bristles during a stroke. The vibration signal may include at least one segment signified by the start of the stroke and the end of the stroke. The vibration signal may include a measurement signal suitable to derive one or more hair properties. The measurement signal may be the signal segment between start and/or end stroke signal signature. For detecting the hair property, extrema below or above a threshold may be canceled. This may include start and/or end stroke detection. Start and/or end stroke may be cancelled by modifying the signal aptitude or by removing. Signal signatures relating to extrema above or below a threshold may be cancelled by modifying the signal aptitude or by removing. For detecting the hair property, the number of strokes may be determined. The hair property may be determined from the processed signal after start stroke, end stroke and/or extrema cancellation. The hair property may be determined from the processed signal by analyzing the processed signal, e.g. by determining a standard deviation, inverse derivative score or similar scores signifying the variation of the signal. The hair property may be determined from more than one processed signal by analyzing the processed signals, e.g. by determining a standard deviation, inverse derivative score or similar score signifying the variation of the signal. The scores may be aggregated for more than one stroke.

The hair property may relate to the condition of the hair detectable via the vibration signal. The hair property may be derived from the vibrational signal of the hair brushed. The hair property may relate to or include one or more hair conditions derivable from the vibrational signal of the hair brushed. The hair conditions may be pre-defined. The hair condition may relate to externally detectable hair conditions, in particular to hair conditions detectable on brushing of the hair, more particular to hair conditions exposing bristles of the hairbrush to mechanical changes such as acceleration, strain, force changes on brushing of the hair. The hair condition may relate to hair properties. Hair conditions may include dryness, damage or breakage, fattiness, thickness, thinness, frizziness, dullness, suppleness, softness, smoothness, shininess or any combinations thereof. Hair properties may include a level of dryness, damage or breakage, fattiness, thickness, thinness, frizziness, dullness, suppleness, softness, smoothness, shininess or any combinations thereof. Detecting the hair property may include generating a score related to at least one hair condition. Detecting the hair property may include generating a score related to a degree or level the at least one hair condition is present for the brushed hair.

In one embodiment detecting the at least one hair property includes generating a score related to at least one hair condition. Generating formulation control data may include determining one or more formulation component(s) based on the hair condition and/or the score. Detecting the hair property may include generating a score related to a degree or level the at least one hair condition is present. The formulation component(s) may be determined or selected from ingredients data based on the hair condition and/or the respective score. An amount or a quantity of respective formulation component(s) may be determined based on the score related to the respective hair condition. The amount or quantity may be a relative or absolute amount provided by the hair product or for producing the hair product. The amount or quantity may relate to a weight percentage or the relative amount of formulation component. The score may relate to the degree or level the hair condition is present. For instance, frizzy hair may be assigned a higher score than smooth hair or hair resulting in higher standard deviation of the vibrational signal may be result in a higher score than lower standard deviations.

In one embodiment the hair property includes a score related to the at least one hair condition. The score may be derivable or derived from the vibrational signal. Generating a score allows for more tailored assessment of the hair condition. Based on the score the formulation components and/or their respective amount may be determined. By determining the score, the hair formulation(s) forming the hair product may be further tailored. For monitoring one or more hair condition(s), the difference between scores associated with the hair condition may be used. The score associated with the hair condition may be determined from at least one current vibrational signal and at least one historical vibrational signal. This way a current score and a historical score may be determined. The difference of the current and the historical score may indicate an evolvement of the hair condition. This way the effectiveness of the treatment may be tracked e.g. by a user.

In another embodiment generating formulation control data includes determining a difference between at least one current hair property and at least one historical hair property and determining one or more formulation component(s) to be used based on the determined difference. Generating formulation control data may include determining a difference between at least one current hair property and at least one historical hair property and providing the at least one current hair property, the at least one historical hair property and/or the difference between at least one current hair property and at least one historical hair property to the user. Generating formulation control data may include determining a difference between at least one current hair property and at least one historical hair property and determining one or more formulation component(s) based on the determined difference between at least one current hair property and at least one historical hair property. This way the hair product may be adapted depending on the effectiveness of the treatment. The at least one current hair property may be detected from the current vibrational signal as disclosed herein. The at least one historical hair property may be detected from historical vibration signals as disclosed herein. The current vibration signal may be the vibration captured and processed for the hair brushed. The historical vibration signal may be a signal retrieved from a data base storing signals of prior hair property detections for hair brushed, preferably including control data generations. Monitoring allows for more targeted treatment over time.

In another embodiment detecting the at least one hair property includes at least one personalized calibration parameter or user-specific calibration parameter. The personalized or user-specific calibration parameter may be determined for the hair brushed from at least one calibration stroke. The determination of the personalized or user-specific calibration parameter may be based on further sensors of the hairbrush such as velocity or rotation sensor. The calibration stroke may include determining stroke properties, such as stroke velocity or stroke angel e.g. as determined by further sensors integrated into the hairbrush. The stroke properties may be mapped to the personalized calibration parameter for detecting the at least one hair property from the vibration signal, e.g. the processed vibration signal. For example, thresholds for extrema reduction may be adapted, the score type may be adapted, the score levels may be adapted, or the start-end-stroke detection may be adapted. Via the calibration parameter user-specific brushing characteristics may be taken into account thus enhancing the hair property detection and the control data generation for treating the brushed hair.

In another embodiment analyzing the vibration signal includes determining one or more signal segment(s) associated with one or more stroke(s) and determining the at least one hair property from the signal segment(s). The signal segments may include a stroke start signature, a stroke end signature and/or a stroke measurement segment. By detecting the stroke start signature and stroke end signature the stroke measurement segment and the hair property may be determined. This way the vibration signal and particular the measurement segment from multiple strokes may be used to enhance hair property detection.

In another embodiment the formulation component relates to at least one base formulation and/or at least one active ingredient. The formulation control data may be generated by selecting one or more formulation component(s) in relation to the determined hair property. The formulation control data may be generated by selecting at least one product comprising one or more formulation component(s) selected in relation to the determined hair property. The formulation control data may specify at least one formulation of the hair product. The formulation control data may specify one or more formulation component(s) making up or contained in the formulation of the hair product, particularly at least one base formulation and/or at least one active ingredient. The formulation control data may specify at least one quantity, such as an amount of the formulation component. The formulation control data may specify at least one component of the formulation.

The formulation control data may specify at least one active ingredient of the formulation. The formulation control data may specify at least one component of the hair formulation. The formulation control data may specify at least one base formulation of the formulation. The formulation control data may be derived from the hair condition and/or the score for the respective hair condition. The formulation control data, particularly related to the formulation component(s) and/or associated quantities, may be derived from the hair condition and/or the score for the respective hair condition.

In another embodiment the formulation control data is usable to produce the hair product containing the one or more formulation component(s), wherein the one or more formulation component(s) to be used for producing the hair product are derived from the at least one hair property.

In another embodiment ingredients data relating to one or more formulation component(s) usable to produce the hair product and/or respective capsule(s) containing formulation component(s) usable to produce the hair product are provided. The ingredients data may relate the at least one hair property to respective formulation component(s) and/or respective capsule(s). The formulation control data may be generated based on the ingredients data by selecting one or more formulation component(s) and/or respective capsule(s) based on the at least one hair property.

In another embodiment ingredients data relates to laboratory measurement data signifying the compatibility of one or more formulation component(s), wherein the formulation control data is generated based on the ingredients data by selecting one or more formulation component(s) based on their compatibility. The ingredients data associated with formulation components usable to produce the hair product may be provided. The ingredients data may relate the at least one hair property, particularly the hair condition(s) and/or associated scores, to respective formulation component(s). The ingredients data may relate to capsule(s) containing formulation component(s) useable, e.g. to be mixed, to produce the hair product. One capsule type may contain one formulation component. One capsule type may contain one base formulation. One capsule type may contain one or more active ingredient(s). One capsule type may contain one or more active ingredient(s) and a base formulation. The ingredients data may relate to different formulation component(s) or respective capsule type(s) or capsule(s) containing formulation component(s) usable to produce the hair product. The ingredients data may relate to different formulation component(s) contained in different capsule(s) or capsule type(s). The ingredients data may relate to laboratory measurement data signifying the compatibility of one or more formulation component(s) e.g. contained in different capsules or capsule types. This way the ingredients data may signify the compatibility of formulation component(s) or capsule(s). The ingredients data may relate to different formulation component(s) contained in capsules and laboratory measurement data signifying the compatibility of the different formulation component(s) with each other. Compatibility may relate to the homogenization behavior, mixing behavior or application behavior of different formulation component(s) contained in different capsules, e.g. when combined. Compatibility may relate to the homogenization behavior, mixing behavior or application behavior of at least one formulation component contained in one capsule and at least one other formulation component contained in another capsule. The formulation control data may be generated based on the ingredients data by selecting one or more formulation component(s), capsule type(s) or capsule(s) based on the at least one hair property, such as the hair condition and/or related scores. The formulation control data may be generated based on the ingredients data by selecting one or more formulation component(s), capsule type(s) or capsule(s) based on their compatibility and/or hair property, such as hair condition and/or score.

In one embodiment generating formulation control data includes determination of capsules containing different formulation component(s). The formulation control data may be determined from the detected hair property, particularly the hair condition and/or respective scores, The hair product may be produced from the one or more formulation

component(s) contained in the capsules. The hair product may be produced from more than one capsule(s), wherein each capsule contains at least one different formulation component. The hair product may be produced from at least one capsule containing the base formulation and at least one capsule containing at least one active ingredient.

In another embodiment the hair property is generated by a data driven model, wherein the data-driven model is trained on a historical dataset including vibration signals, hair properties, scores and/or characteristics of the hair brushed to provide at least hair properties and/or scores. The hair characteristics may include user data such as user's age, length of the hair, hair state like virgin or colored, hair type like brown thick hair or blonde thin hair. The data-driven model may be trained to receive at least a portion of the vibration signal and, in response to receipt of at least the portion of the vibration signal to output at least one or more hair properties and/or scores associated with the hair to be brushed. The data-driven model may be trained based on vibration signal including measurement segment of one or more strokes and associated hair properties and/or scores. The data-driven model may be trained based on processed vibration signal including measurement segment of one or more strokes and excluding extrema such as stroke start and end signatures. The historical dataset may include historical vibration signals annotated by determined hair properties, scores and/or characteristics of the hair brushed. The data-driven model may be trained based on scores. The historical dataset may include historical scores of vibration signals annotated by determined hair properties and/or characteristics of the hair brushed. The historical dataset may include historical vibration signals and/or derived scores collected under lab conditions and/or as determined for other users. Such data may be annotated by determined hair properties, if applicable scores and/or characteristics of the hair brushed. This way hair properties determined e.g. under lab conditions or for other users may be made available to the hair property detection allowing for more reliable hair property detection and more nuanced control data generation.

In another embodiment the formulation control data is generated by a data driven model, wherein the data-driven model is trained on a historical dataset including vibration signals, hair properties, scores, characteristics of the hair brushed and/or formulation component(s) to be used to provide at least formulations component(s). The historical dataset may additionally or alternatively include differences signifying treatment effectiveness. The data-driven model may be trained to receive at least a portion of the vibration signal and, in response to receipt of at least the portion of the vibration signal to output at least formulation component(s) to be used for the hair brushed. The data-driven model may be trained to receive at least a portion of the vibration signal, characteristics of the hair brushed and/or differences determined for treatment effectiveness, and, in response to receipt of at least the portion of the vibration signal, characteristics of the hair brushed and/or differences determined for treatment effectiveness to output one or more formulation component(s) to be used for treatment of the hair brushed. The data-driven model may be trained based on vibration signals including measurement segment of one or more strokes and associated hair properties and/or scores. The historical dataset may include historical vibration signals annotated by determined hair properties, scores, characteristics of the hair brushed, formulation component(s) to be used and/or differences determined for treatment effectiveness. By including historical formulation component determinations and differences signifying

treatment effectiveness in combination with measurement, the hair property detection and formulation control data generation can be enhanced.

In another embodiment the formulation component relates to a base formulation and/or an active ingredient. At least one base formulation and at least one active ingredient or at least first active ingredient(s) and second active ingredient(s) to be used for providing or producing the hair product may be derived from the at least one hair property associated with the brushed hair. A combination of at least one base formulation and one or more active ingredient(s) to be used for providing or producing the hair product or of at least first active ingredient(s) and second active ingredient(s) to be used for providing or producing the hair product may be derived from the at least one hair property, such as the hair condition and/or score. At least one base formulation and/or at least one active ingredient may be derived from the at least one hair property associated with the hair brushed. Depending on at least one active ingredient derived from the at least one hair property at least one base formulation may be selected.

In further embodiments the generation of formulation control data may include providing data related to the user and deriving/generating formulation control data based on data related to the user, such as hair characteristics including hair length, hair state like virgin or colored, and/or hair type like brown thick hair or blonde thin hair, location, time or user specific data. Data related to the user may include weather data or sun exposure data associated with the user's location, pollution exposure data associated with the user's location, the user's age, the user's treatment plan or combinations thereof. Sun exposure or weather data may be used for the generation of formulation control data, e.g. UV filters may be selected as active ingredient. Pollution exposure data may be used for the generation of formulation control data, e.g. polymers shielding the hair, such as natural cationic proteins or antioxidants, may be selected as active ingredient. The user's age may be used for the generation of formulation control data e.g. active ingredients suitable to treat hair for the specific age may be selected as active ingredient. The user's treatment plan may be derived from historic monitoring of the user's hair condition. The effectiveness of the treatment may be determined from such monitoring data and used for generating formulation control data, e.g. an active ingredient is changed based on the monitoring signifying the ineffectiveness of the prior used active ingredient. The user's treatment plan may be derived from the time the vibration signal is captured or the formulation control data is generated and used for generating formulation control data, e.g. at day time UV filters may be selected as active ingredient or at night time oils may be selected as base formulation. Hair characteristics including user's age, hair length, hair state, and/or hair type may be used for the generation of formulation control data, e.g. by including data related to the user into the formulation component selection, e.g. by the ingredients data.

The formulation control data may specify the active ingredient(s) associated with the hair property, such as the hair condition and/or the score related to the respective hair condition. The formulation data may specify the quantity of active ingredient(s) associated with the hair property, such as the hair condition and the score. The quantity of active ingredient may relate to the weight percentage of active ingredient or the relative amount of active ingredient. The

formulation data, particularly the active ingredient(s) and associated quantities, may be derived from the hair property, such as the hair condition and the score. The active ingredients may be pre-defined. The ingredients data may specify one or more active ingredients per hair property, such as hair condition and/or score. For generation of the formulation control data, one or more active ingredient(s) may be selected from ingredients data based on the hair property, such as hair condition and/or score. The ingredients data may specify one or more base formulation(s) per hair property, such as hair condition and/or score, per active ingredient. For generation of the formulation control data, one or more base formulation(s) may be selected from ingredients data based on the hair property, such as hair condition and/or score, the sub-area and/or the active ingredient(s).

The formulation control data may specify the base formulation ingredient(s) associated with the hair property, such as the hair condition and the score. The formulation control data may specify the quantity of ingredient(s) for the base formulation associated with the hair property, such as the hair condition and/or the score. The formulation control data, particularly the ingredient(s) for the base formulation and associated quantities, may be derived from the hair property, such as the hair condition and the score.

In another embodiment the production of the hair product includes mixing the formulation components specified via the formulation control data. For mixing, the formulation control data may specify at least two capsules with different formulation components, such as a first capsule containing the base formulation and at least one second capsule containing active ingredient(s) or such as a first capsule containing first active ingredient(s) and at least one second capsule containing at least second active ingredient(s). The at least two capsules with different formulation components may be provided to a mixing unit. The content of the capsules may be mixed to provide the hair product, such as a shampoo or conditioner containing active ingredients. The mixing device may include at least one dosing nozzle for releasing at least one base formulation and/or at least one active ingredient. The mixing device may include a mixing unit for mixing at least one base formulation and at least one active ingredient.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the present disclosure is further described with reference to the enclosed figures:

Fig. 1 illustrates schematically an example system for measuring hair property by way of a hairbrush through brushing the hair of a subject,

Fig. 2 illustrates schematically an example of processing vibration signals.

Figs. 3a to 5c show experimental results of determining a hair property utilizing the system for assessing hair property.

Fig. 6 illustrates schematically an example of a flow chart for detecting at least one hair property from the vibrational signal and generating formulation control data.

Fig. 7 illustrates schematically an example of a mixing device for mixing a hair product to be applied to the brushed hair.

Fig. 1 illustrates schematically an example system 100 for measuring hair property by way of a hairbrush through brushing the hair of a subject.

The system 100 comprises a hairbrush 110 for brushing hair of a subject and an apparatus 120 for assessing the hair property of the hair being brushed. The apparatus 120 may be in communicative contact to or integrated as part of a hardware and/or software into a computational user device 130, like a smartphone. The apparatus 120 may be a standalone device specifically usable for determining the hair property. The apparatus 120 may be integrated into the hairbrush 110, for instance, into a handle of the hairbrush 110.

The hairbrush 110 may include any brush comprising a hairbrush body 115 and a plurality of bristles 111 attached to the hairbrush body 115. The bristles 111 may be attached to a flexible part 116 of the hairbrush body 111 or may be directly attached to the hairbrush 110. The bristles 111 may include metal or synthetic bristles attached to the hair-brush body 111. For example, in the embodiment shown in Fig. 1 the bristles 111 are attached via a bristle support structure, here realized as a flexible part 116, e.g. flexible membrane, to the main body 115 of the hair-brush 110.

The hairbrush 110 may comprise one or more vibration sensors 112 integrated into the hairbrush 110. In the example shown in Fig. 1, two vibration sensors 112 are integrated into the hairbrush 110. Different configurations may be realized such as one sensor may be integrated into the hairbrush 110 or more than two sensors may be integrated into the hairbrush 110. The vibration sensors 112 may be integrated into the hairbrush 110 by attaching the vibration sensors to one or more bristle(s) 111 of the hairbrush 110. An adhesive 113 for adhering the vibration sensors 112 to the bristles 111, in particular a silicone-based adhesive, may be utilized. However, also other methods for adhering or attaching the vibration sensors to one or more of the bristles 111 can be utilized that allow the vibration sensors 112 to measure the vibrations of the bristles 111.

In the example shown in Fig. 1, the utilized adhesive 113 allows a vibration sensor 112 to measure the vibrations of one or more bristle(s) 111, in particular, more than one bristle 111 connected to the vibration sensor 112 via the adhesive 113. The vibration sensor 112 may be associated with one or more bristle(s) 111. Integrating the one or more vibration sensors 112 such that each vibration sensor 112 can measure the vibrations of one bristle 111 allows for a suitable accuracy for determining a hair property. Arranging the vibration sensor 112 such that it can measure the vibrations of more than one bristle(s) 111 allows to measure a more accurate vibration signal and allows to reduce exceptional outliers and other abnormalities in the vibration measurement signal.

The vibration sensors 112 may include any kind of sensor that allows to measure vibrations of the bristles 111, e.g. that allows to provide a measurement signal that is indicative of the back-and-forth movements of the bristles 111 during a brushing stroke through the hair of a subject. The vibration sensors 112 may include acceleration sensors that measure an acceleration in the vibration movement of the bristles 111. The vibration sensors 112 may include velocity sensors that measure a velocity of the bristles 111 during the brushing of the hair or position sensors that measure a position or a change in position of the bristles 111. The hairbrush 110 may further comprise a velocity sensor 117 and/or a rotation sensor 118. The velocity sensor 117 may be integrated into the hairbrush 110 such that it can measure an overall velocity of the hairbrush 110 during the brushing. The rotation sensor 118 may be integrated into the hairbrush 110 such that it can measure an overall rotation, such as a degree of rotation of the hairbrush 110. The sensors mentioned above, such as the vibration sensors 112, the velocity sensor 117 and the rotation sensor 118, can be adapted to either measure an absolute value of the respective measurement quantity or a relative value and thus a change of the respective measurement quantity. Further sensors like an acoustic sensor, an image sensor, a humidity sensor, and/or a force sensor can additionally or alternatively be integrated into the hairbrush 110.

The one or more sensor(s) may be communicatively coupled to the apparatus 120 as indicated by the wireless communication signals 114 and 123. The communicative coupling between the sensors 112, 117, 118 and the apparatus 120 may depend on the respective realization of the apparatus 120. For example, if the apparatus 120 is integrated into a handle of the hairbrush 110, the communicative coupling can be provided by respective signal cables. If the apparatus 120 is realized as a standalone device, or is part of a computational device of a user, the communicative coupling may be realized in form of wireless communication signals utilizing any known wireless communication technique. A dedicated communication unit, not shown in Fig. 1, may be provided as part of the hairbrush 110 to which the sensors are communicatively coupled, for instance, utilizing communication signal wires, wherein the communication unit is then adapted to forward the measurement signals of the sensors to the apparatus 120 via the known wireless communication technique.

The apparatus 120 may comprise a vibration measurement providing unit 121 and a hair property determination unit 122. The vibration measurement providing unit 121 may be adapted to provide the vibration signals that are indicative of the result of the vibration measurements performed by the one or more vibration sensors 112. The vibration measurement providing unit 121 may be adapted as a receiving unit for directly receiving the vibration signals measured by the vibration sensors 112 and for providing the received vibration signals. The vibration signals measured by the vibration sensors 112 may be provided to a storage unit, for instance, to a cloud storage, wherein in this case the vibration measurement providing unit 121 may be adapted to access the respective storage unit and to provide the stored vibration signals to the hair property determination unit 122. The vibration signal may be indicative of the vibrations of the bristles 111 of the hairbrush 110 during the brushing of the hair of a subject.

The hair property determination unit 122 may be adapted to determine one or more hair properties based on the respective vibration signals. The vibration signals of the bristles 111 of a hairbrush 110 may be suitable to determine a

plurality of hair properties, for instance, a type of the hair, how the hair was treated in the past, and, in particular, a quality of the hair, i.e. whether and to which degree the hair has been damaged. The hair property determination unit 122 may be adapted to analyze the vibration signal associated with the respective hair properties. For example, a standard deviation from an average signal value or a span width of a second integration or inverse derivative of the vibration signal may be correlated with hair property, such as a hair quality and subtleness of the hair.

The hair property determination unit 122 may utilize the results of the velocity measurement provided by the velocity sensor 117 and the results of the rotation measurement provided by the rotation sensor 118 for determining one or more hair properties. In particular, these additional signals may be utilized for further increasing an accuracy of the determination of the hair property. For example, based on the velocity signal provided by the velocity sensor 117, the beginnings and endings of hair strokes may be determined, and the velocity of the different hair strokes may be compared. This allows to utilize, for instance, only vibration signals coming from brushing strokes performed with the velocity of the hairbrush 110 in a predetermined range. Accordingly, it can be avoided to compare brushing strokes performed with strongly deviating velocities which might lead to respective strongly deviating vibrations of the bristles of the hairbrush. Moreover, also the angle between the hairbrush and the hair with which the brushing is performed can have an influence on the respective vibration of the bristles. Thus, taking the degree of rotation provided by the rotation sensor 118 into account during the hair property determination allows to utilize the vibration signals of brushing strokes within a predetermined degree of rotation of the hairbrush 110. The signals of other sensor(s) may be utilized by the hair property determination unit 122 to improve the measurements of the hair property, for example, by utilizing predetermined rules on how and when to combine the respective signals for determining the hair property.

The result of the hair property determination, such as the respective hair property like the respective quality of the hair, can then be provided to a user device 130 and can be displayed, for instance, on display 131. The result may include a hair quality score and may be presented on the display 131 of the user device 130, for instance, by utilizing a respective app on the user device 130. However, the result can also be provided to a user in other forms, for instance, via a light or a small display provided as part of the hairbrush 110 or via an audio signal like a beep or a voice to a loudspeaker that can be provided to the user device 130 or can also be provided to the hairbrush 110. Moreover, information to the user, like a result, can also be provided to a user via a loading and/or base station of the hairbrush.

Fig. 2 illustrates an example of processing vibration signals.

The top graph illustrates an example of the raw data vibration signal. The raw data includes multiple strokes. The strokes are signified by the start and end signatures per stroke. Th start and end signatures show a high amplitude owing to the force acting on the bristles on the start and end of each stroke. The segment between the start and end signature is the measurement signal, from which the hair property may be determined.

The bottom graph illustrates one stroke with start signature, end signature and measurement segment. The amplitude extrema are reduced by cutting the amplitude at a high and low threshold or by removing respective data points.

In the example shown, the start and end amplitudes are detected and cut back to the threshold. In other examples, outliers in the measurement segment may be removed. From the measurement segment the standard deviation may be determined as one possible indicator for score. The standard deviation may be determined per stroke. The standard deviations per stroke may be aggregated e.g. as mean standard deviation. The standard deviation is only one example and other analysis indicators for scoring hair conditions may be determined. The indicator for scoring may be mapped to the hair property in the sense of a level or range signifying a level or range related to the hair condition. For example, the high standard deviation may signify a suppleness level and based on such level formulation control data including formulation components may be provided.

In Figs. 3a to 5c example determinations of the hair property with the hairbrush 110 will be described in more detail utilizing the hairbrush 110 as described for example in the context of Fig. 1. The hairbrush used on the following examples includes piezo electric element(s) as vibration sensor(s) attached to the bottom side of the hairbrush membrane with the silicone adhesive.

In Figs. 3a and b the differentiation of good and bad quality hair is illustrated. The good and bad quality hair may me defined by the vibration spectrum associated with damaged hair. The hair property is in this example the hair quality, which can be assessed based on the vibration spectrum and scores such as ADC value determined from the vibration spectrum. Fig. 3a shows that the standard deviations of the ADC vibration signals for good and bad hair can be classified based on the vibration signals. The Fig. 3a shows that the average values of the ADC signals are comparable, but that a differentiation of the two different hair qualities is possible by the deviation of the standard deviations of the signal values from the average into good and bad.

In a further example, shown in Fig. 3b the density of bristles of the hairbrush was increased with multiple bristles per sensor. The silicone adhesive was used to connect the vibration sensor to a plurality of bristles of the hairbrush 110. Although already in the above example, the differentiation was easily possible, Fig. 3b shows that by connecting a plurality of bristles to the vibration sensor the possible differentiation of good and bad hair quality can be increased up to 300%. Thus, the accuracy of a hair quality determination can be increased.

In the examples of Fig. 4a and b, differently damaged Caucasian hair were evaluated utilizing the hairbrush 110 as described for example in the context of Fig. 1. In this case, the vibrational sensor signal was translated into an acceleration and the acceleration signals of the vibrational sensor were recorded over time. By applying a second integration to the signal the displacement can be determined. The hair property in this example is the degree of damage of hair and the related score is the second integration signifying the level of damage.

Fig. 4a shows the result of the second integration of the vibration signal for undamaged hair and Fig. 4b for damaged hair, in this case in particular bleached hair. The second integration of the acceleration signal results in displacement values, shown on the right of the Figs. 4a and 4b that can then be further evaluated for determining the hair quality or other properties. For example, as shown in Fig. 4b the span width of the maximum and minimum values of the

second integration signal can be determined. As can be derived from Fig. 4a and 4b the second integrated signal from medium-bleached hair can be more distinct than a second integrated signal from the untreated, i.e. virgin, hair. Figure 4c shows the significantly different mean values of the span width of five virgin hair strands and of five medium-bleached hair strands both evaluated after the second integration.

In a further example, mannequin heads had been washed with 3 different shampoos from a drugstore. The three mannequin heads were washed twice with different shampoos A, B, C and dried overnight. Suppleness using Caucasian hair strands had been evaluated by measuring residual dry combing work before the shampoos were applied. Figs. 5a-c show the result. The lower the values of the residual dry combing work, the easier the dry combing and the better the smoothness and softness of the hair strands. In this example the hair property is the level of suppleness of the hair, which is signified by the second integration or second inverse derivative of the signal as score.

Each mannequin head associated with a different shampoo was combed with a hairbrush as described above. In this experiment the hairbrush was used manually with 3 combing strokes at 10 repetitions. Moreover, for each mannequin a suppleness of the hair was measured. For example, a dry hair strand of the mannequin was pulled through a displacement configuration, e.g. a number of rings alternatingly spaced apart, and the force necessary for pulling the hair strand through the displacement was measured. The measured force is then indicative of the suppleness of the hair stand, in particular, the lower the pulling force the higher the suppleness. Fig. 5B show mean span width values after second integration of the acceleration signals, calculated as described above, in relation to a measured suppleness for the three different shampoos. Fig 5A shows for the same experimental setup the calculated mean span width values after second integration of the acceleration signals in relation to residual dry combing work values for the three shampoos. For measuring the dry combing work values hair strands of the respective mannequin heads can be combed with a predefined configuration of combs that are oppositely arranged and the force can then be measured that is needed for pulling the hair strand through the comb arrangement. From the force the dry combing work can then be derived. Moreover, Fig. 5C shows for all three shampoos the relation between the suppleness and the residual dry combing work values. Figs. 5A, 5B and 5C show that the characteristics of the vibration signal, here the span width of the second integrated vibration signal, allow for an accurate differentiation between hair with different properties, here different suppleness or dry combing work values. Moreover, since the different hair properties are caused by different shampoos, the utilization of the vibration signal for determining the hair properties allows even to determine the influence of hair care products on the hair of a user.

All the above examples indicate the vibration signals of bristles determined utilizing the hairbrush as described above allow for an accurate determination of a hair property, in particular, of a hair quality, damage level or suppleness. Moreover, vibration signals provided by respectively integrated vibration sensors in the hairbrush are suitable to differentiate between differently damaged hair and different hair treatments which makes it an easy way to use the device for hairdressers and consumers for helping with the selection of respective hair care products for an individual user.

The “smart” hairbrush utilizes one or more vibration sensor(s) to analyze different hair properties, in particular, hair qualities, while brushing. Generally, there is a growing trend for home-use evaluation of hair care products by end-consumers themselves. The evaluation becomes possible by providing “smart” devices, i.e. mainly wireless standalone devices that are able to track individual hair and scalp condition and/or improvement. However, there are more scalp and less hair evaluation devices available on the market. Moreover, there is also a need to get a reliable and efficient device which can be directly and easily used by the end-consumer. The tech-unique of the respective device should be self-explaining and the results of the application should be visible either directly on the device or on a connected cell phone. There are some devices for hair analysis today, which, however, are complex e.g. based on NIR technology or lab diagnostics only designed for usage by hairdressers, i.e. professionals. Other devices for hair evaluation, which are described in literature or other media, cannot be purchased or are only using imaging techniques which is often incomprehensible and inapplicable for the consumer. These devices are in particular costly and the information provided by the devices often inaccurate such that probably no consumer would be prepared to spend money for this kind of information.

In this context, it was found that from vibration signals of the bristles of a hairbrush hair properties can be accurately and easily derived. Thus, a hairbrush for hair property analysis using vibration sensor(s) can be advantageously utilized for hair property analysis. For example, a vibration sensor can be utilized that is adapted to detect vibration from 10 Hz to 15 kHz through a piezo ceramic material base sensor with vibration signal amplification circuit integration. Such a hairbrush together with the respective apparatus, as described in the examples above, can be easily used during daily hair treatment without additional hair expertise.

It is further noted, that generally there are a lot of other approaches for smart hair analysis, like utilizing infrared light, ultraviolet light, visible light respectively imaging, force or sound measurements, but that all these techniques have certain drawbacks. Especially the evaluation of absorption curves from different light sources can be impaired by product residues on hair. Force and sound measurements strongly depend on individual consumer application and hair style. In contrast thereto utilizing a vibration sensor is a very robust technique which can directly measure the health status of the hair fiber. Healthy hair is very smooth and flexible. Damage caused by different hair treatment, like bleaching, UV irradiation or straightening by heat or chemicals, or even hair washing results in more brittle hair fibers. Hereby hair proteins are oxidized, hair lipids are lost and the natural appearance of the hair is impaired. Thus, the vibration signal analysis as described in this application can be utilized to allow users to avoid these damages and to provide respective indications how such damages can be repaired. The vibration sensor technology is unique and can be integrated in standard hairbrushes.

Fig. 6 illustrates schematically an example of a flow chart for detecting at least one hair property from the vibrational signal and generating formulation control data.

The hairbrush 110 described above, e.g. in the context of Fig. 1, may be used in connection with a mobile hair application. Depending on the user the application, in particular the analysis of the signal may be calibrated. The user

may register with the mobile hair application. On registration the user may calibrate the analysis of the vibration signal from the hairbrush 110. This may depend for example on the user's pattern of brushing the hair. Vibration signal from one or more calibration strokes may be provided e.g. to the hairbrush interface of the mobile application the hairbrush 110 is communicatively connected to. The vibration signal may be analyzed as for example described in the context of Fig. 2. The signal may be processed to remove the start and end stroke signature and to extract the measurement segment. The thresholds for extrema reduction or cancellation may be adapted to the user specific signal. Scores such as standard deviation or second inverse derivative and their mapping to the thresholds for the hair condition may be determined to enable detecting of the hair property. For determining the user-specific calibration parameter further sensors such as rotation and/lor velocity sensors signifying user specific brushing properties may be used. The user specific calibration parameters may be stored in association with the user profile, such as a user ID provided on registration.

For using the hairbrush 110 to provide and/or produce the hair product containing the one or more formulation component(s) to be used, the vibration signal as measured by the hairbrush 110 may be provided to the hairbrush interface e.g. of the mobile application. The calibration parameters or calibrated parameters stored on calibration may be provided. The hair property associated with the hair brushed may be detected by analyzing the vibration signal. Analyzing the vibration signal may include determining one or more signal segment(s) associated with one or more stroke(s) and determining the at least one hair property from the signal segment(s). Analyzing may include generating a score related to the at least one hair condition to determine the hair property. Determining the at least one hair property may include the personalized calibration parameter. The personalized calibration parameters may be determined for the hair brushed from at least one calibration stroke. The calibration stroke may include determining stroke properties, such as the user's personalized profile to brush hair. The calibration parameter or calibrated parameters may be used for detecting the at least one hair property from the vibration signal as described above.

Determining the at least one hair property may include mapping the determined score to thresholds for the hair condition to determine a level or range the score lies in for the hair condition providing the hair property. For example, the score, such as the standard deviation or second inverse derivative, may indicate the suppleness of the hair or the level of damage of the hair.

The hair property may be generated by mapping the vibrational signal by a data driven model to the hair property. The data-driven model may be trained on a historical dataset including vibration signals, hair properties, scores, and/or characteristics of the hair brushed. The data-driven model may be trained on measured vibration signals and respective hair properties. The data-driven model may be trained on measured vibration signals, respective hair properties and characteristics influencing the hair, such as hair characteristics like length, exposure of the hair to environmental influences such as sun or pollution, hair state such as virgin or bleached, origin, used hair products or age. The vibrational signal may be fed to the data-driven model and the data-driven model may provide the hair property, e.g. the hair condition and the respective score. The vibration signal may be processed to determine the score and the score may be fed to the data driven model to provide the hair property. The data driven model may be

trained on respective historical data sets. The historical dataset may include historical vibration signals annotated by determined hair properties, scores and/or characteristics of the hair brushed. The historical dataset may include historical scores derived from vibration signals annotated by determined hair properties, and/or characteristics of the hair brushed. The historical dataset may include historical vibration signals or scores collected under lab conditions and/or as determined for other users. Such data may be annotated by determined hair properties, and/or characteristics of the hair brushed. This way hair properties determined e.g. under lab conditions or for other users may be made available to the hair property detection allowing for more reliable hair property detection and more nuanced control data generation. The hair characteristics may include user data such as user's age, length of the hair, hair state like virgin or colored, hair type like brown thick hair or blonde thin hair. The data-driven model may be based on a regression model. The data-driven model may be based on a neural network structure including at least one encoder and at least one decoder. The data-driven model may be based on a convolutional neural network structure and/or a recurrent neural network structure.

The formulation control data may be generated by deriving one or more formulation component(s) from the at least one detected hair property associated with the hair brushed. The formulation component may relate to at least one base formulation and/or at least one active ingredient. Generating formulation control data may include determining one or more formulation component(s) based on the hair condition and the associated score.

The formulation control data may be generated by selecting one or more formulation component(s) in relation to the determined hair property, wherein the formulation control data is generated by selecting at least one product comprising one or more formulation component(s) selected in relation to the determined hair property. Generating formulation control data may include mapping the formulation component(s) to pre-set product(s) or product formulation component(s) containing the formulation component(s). The pre-set products(s) may be provided including the used formulation component(s) for selection.

For mapping ingredients data relating to one or more formulation component(s) may be provided. Ingredients data may relate to laboratory measurement data signifying the compatibility of one or more formulation component(s). The formulation control data may be generated based on the ingredients data by selecting one or more formulation component(s) based on their compatibility. If a product is to be produced, the formulation component(s) usable to produce the hair product and/or respective capsule(s) containing formulation component(s) usable to produce the hair product may be provided. The ingredients data may relate the at least one hair property to respective formulation component(s) and/or respective capsule(s). The formulation control data may be generated based on the ingredients data by selecting one or more formulation component(s) and/or respective capsule(s) based on the at least one hair property.

Generating formulation control data may include determining a difference between at least one current hair property and at least one historical hair property and providing the at least one current hair property, the at least one historical

hair property and/or the difference between at least one current hair property and at least one historical hair property to the user.

The formulation control data may be generated by a data driven model. The data-driven model may be trained on a historical dataset including vibration signals, scores, hair properties, characteristics of the hair brushed, differences determined for evaluating treatment effectiveness and/or formulation component(s) to be used or ingredients data. The data-driven model may be trained on a historical dataset including vibration signals, hair properties, scores, characteristics of the hair brushed differences determined for evaluating treatment effectiveness, and/or formulation component(s) to be used. The vibrational signal may be fed to the data-driven model and the data-driven model may provide the formulation component(s) to be used. The processed vibrational signal or scores may be fed to the data-driven model and the data-driven model may provide the formulation component(s) to be used. The data-driven model may further provide the hair property, e.g. the hair condition and the respective score. The determined formulation component(s) may be mapped to pre-set product(s) or product formulation component(s) containing the formulation component(s). The pre-set products(s) may be provided based on the output of the data-driven model. By including historical formulation component determinations and differences signifying treatment effectiveness in combination with measurement data into account, the hair property detection and formulation control data can be enhanced to increase the likelihood of successful hair treatment. The data-driven model may be based on a regression model. The data-driven model may be based on a neural network structure including at least one encoder and at least one decoder. The data-driven model may be based on a convolutional neural network structure and/or a recurrent neural network structure.

Generating formulation control data may include determining a difference between at least one current hair property and at least one historical hair property and determining one or more formulation component(s) to be used based on the determined difference. This may allow for monitoring the hair property.

The formulation control data usable to provide the hair product containing the one or more formulation component(s) to be used may be provided. The formulation control data may be usable to produce the hair product containing the one or more formulation component(s). The one or more formulation component(s) to be used for producing the hair product may be derived from the vibration signal or the at least one detected hair property.

Fig. 7 illustrates schematically an example of a mixing device for mixing a customized hair product to be applied to the brushed hair.

The formulation control data may be generated as described in the context of Fig. 6. The formulation control data may include formulation mixing data. The formulation control data may relate to ingredients to be used and the amount or quantity of ingredients to be used for producing the hair product.

The formulation control data may be provided to the mixing device 202. Deriving formulation control data may include determination of capsules containing different formulation component(s). The formulation control data may be provided to select capsules for mixing, that contain the respective formulation components. The hair product may be produced from the one or more formulation component(s) contained in the capsules. The hair product may be produced from more than one capsule(s), wherein each capsule contains a different formulation component. The hair product may be produced from at least one capsule containing the base formulation and at least one capsule containing at least one active ingredient. The capsules may be placed in the ingredients tank of the mixing machine. The formulation control data may be provided to the ingredients tank control to control release of ingredients for mixing. Based on the formulation control data the hair product 200 with the tailored formulation may be produced and provided. The formulation may be applied to the hair of the user reflected in the vibration signal.

This way personalized hair treatment can be further individualized to the user's needs. Through the tailored hair treatment, the use of ingredient resources can be targeted to the user's needs thus contributing to environmentally friendly hair treatment.

The present disclosure has been described in conjunction with preferred embodiments and examples as well. However, other variations can be understood and effected by those persons skilled in the art and practicing the claimed invention, from the studies of the drawings, this disclosure and the claims.

Any steps presented herein can be performed in any order. The methods disclosed herein are not limited to a specific order of these steps. It is also not required that the different steps are performed at a certain place or in a certain computing node of a distributed system, i.e. each of the steps may be performed at different computing nodes using different equipment/data processing.

As used herein „determining" also includes „initiating or causing to determine", "generating" also includes „initiating and/or causing to generate" and "providing" also includes "initiating or causing to determine, generate, select, send and/or receive". "Initiating or causing to perform an action" includes any processing signal that triggers a computing node or device to perform the respective action.

In the claims as well as in the description the word "comprising" does not exclude other elements or steps and the indefinite article "a" or "an" does not exclude a plurality. A single element or other unit may fulfill the functions of several entities or items recited in the claims. The mere fact that certain measures are recited in the mutual different dependent claims does not indicate that a combination of these measures cannot be used in an advantageous implementation.

Any disclosure and embodiments described herein relate to the methods, the systems, devices, the computer program element lined out above and vice versa. Advantageously, the benefits provided by any of the embodiments and

examples equally apply to all other embodiments and examples and vice versa. All terms and definitions used herein are understood broadly and have their general meaning.

Claims

1. A method for generating formulation control data for providing a hair product for treating one or more hair conditions, the method comprising:
   - providing a vibration signal measured by a hairbrush (110) including bristles connected to one or more vibration sensor(s),
   - detecting at least one hair property associated with the hair brushed by analyzing the vibration signal,
   - generating formulation control data by deriving one or more formulation component(s) from the at least one detected hair property associated with the hair brushed,
   - providing the formulation control data usable to provide the hair product containing the one or more formulation component(s) to be used.

2. The method of claim 1, wherein detecting the at least one hair property includes generating a score related to the at least one hair condition, wherein generating formulation control data includes determining one or more formulation component(s) based on the hair condition and the score.

3. The method of any of the preceding claims, wherein detecting the at least one hair property includes a personalized calibration parameter, wherein the personalized calibration parameter is determined for the hair brushed from at least one calibration stroke, wherein the calibration stroke includes determining stroke properties, wherein the stroke properties are mapped to the personalized calibration parameter for detecting the at least one hair property from the vibration signal.

4. The method of any of the preceding claims, wherein analyzing the vibration signal includes determining one or more signal segment(s) associated with one or more stroke(s) and determining the at least one hair property from the signal segment(s).

5. The method of any of the preceding claims, wherein the formulation component relates to a at least one base formulation and/or at least one active ingredient, wherein the formulation control data is generated by selecting one or more formulation component(s) in relation to the detected at least one hair property, wherein the formulation control data is generated by selecting at least one product comprising one or more formulation component(s) selected in relation to the detected at least one hair property.

6. The method of any of the preceding claims, wherein the formulation control data is usable to produce the hair product containing the one or more formulation component(s), wherein the one or more formulation component(s) to be used for producing the hair product are derived from the detected at least one hair property.

7. The method of any of the preceding claims, wherein ingredients data relating to one or more formulation component(s) usable to produce the hair product and/or respective capsule(s) containing formulation

component(s) usable to produce the hair product are provided, wherein the ingredients data relate the at least one hair property to respective formulation component(s) and/or respective capsule(s), wherein the formulation control data is generated based on the ingredients data by selecting one or more formulation component(s) and/or respective capsule(s) based on the at least one hair property.

8. The method of claim 7, wherein ingredients data relates to laboratory measurement data signifying the compatibility of one or more formulation component(s), wherein the formulation control data is generated based on the ingredients data by selecting one or more formulation component(s) based on their compatibility.

9. The method of any of the preceding claims, wherein the hair property is generated by a data driven model, wherein the data-driven model is trained on a historical dataset including vibration signals, hair properties, scores, and/or characteristics of the hair brushed to provide at least hair properties and/or scores.

10. The method of any of the preceding claims, wherein the formulation control data is generated by a data driven model, wherein the data-driven model is trained on a historical dataset including vibration signals, hair properties, characteristics of the hair brushed and/or formulation component(s) to be used to provide at least formulation component(s).

11. The method of any of the preceding claims, wherein generating formulation control data includes determining a difference between at least one current hair property and at least one historical hair property and determining one or more formulation component(s) to be used based on the determined difference.

12. The method of any of the preceding claims, wherein generating formulation control data includes determining a difference between at least one current hair property and at least one historical hair property and providing the at least one current hair property, the at least one historical hair property and/or the difference between at least one current hair property and at least one historical hair property to a user.

13. An apparatus for generating formulation control data for providing a hair product for treating one or more hair condition(s), the method comprising:

- a hairbrush configured to provide a vibration signal measured by the hairbrush (110) including bristles connected to one or more vibration sensor(s),
- a detector configured to detect at least one hair property associated with the hair brushed by analyzing the vibration signal,
- a generator configured to generate formulation control data by deriving one or more formulation component(s) from the at least one detected hair property associated with the hair brushed,
- a control data providing interface configured to provide the formulation control data usable to provide the hair product containing the one or more formulation component(s) to be used.

14. Use of the formulation control data as generated according to the methods of any claims 1 to 12 or as generated by the apparatus according to claim 13 to provide or produce a hair product.

15. A computer element, which when executed by a computing system, direct the computing system to generate control data according to the computer-implemented methods of any of claims 1 to 12 or as generated by the apparatus according to claim 13.

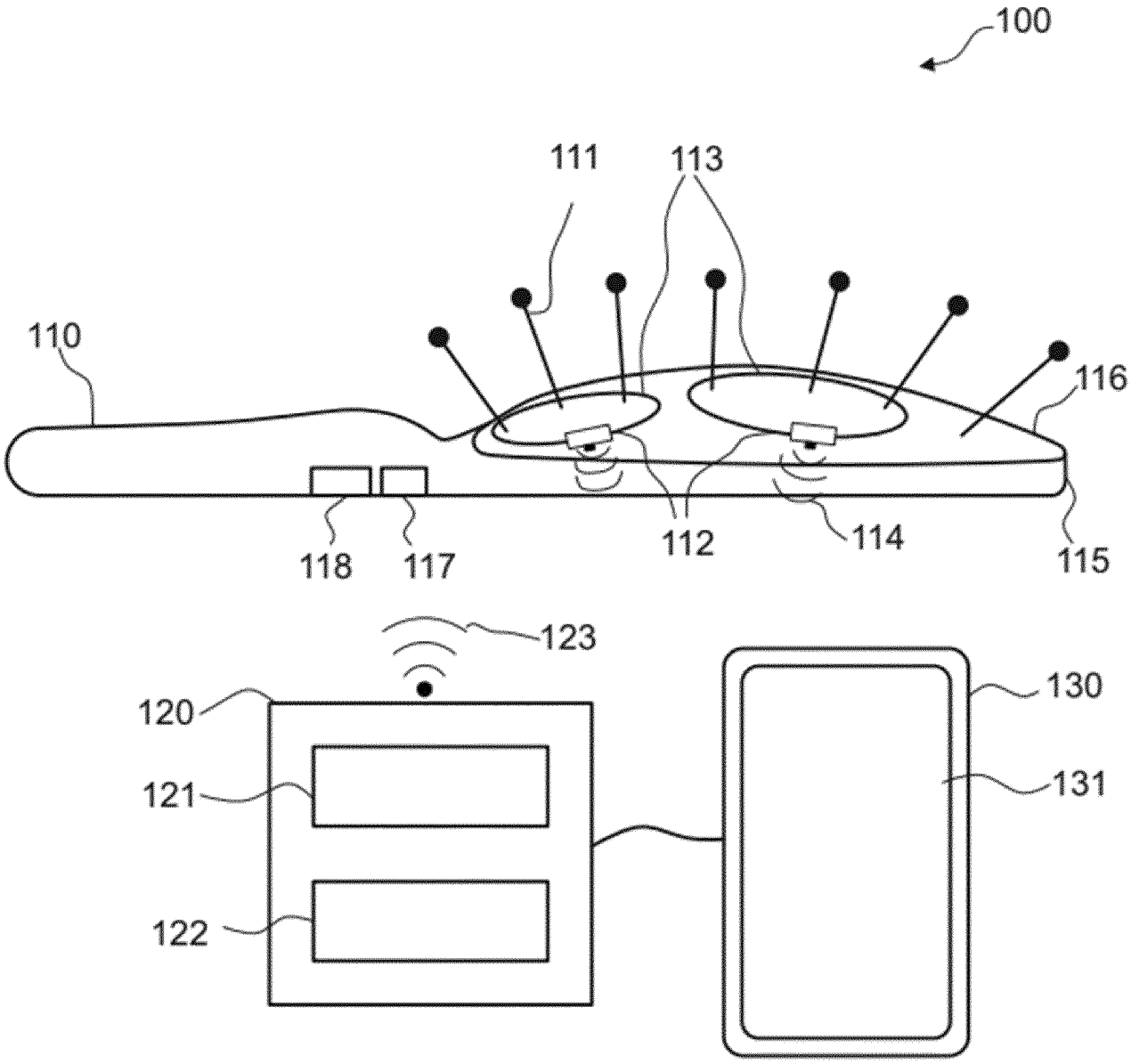
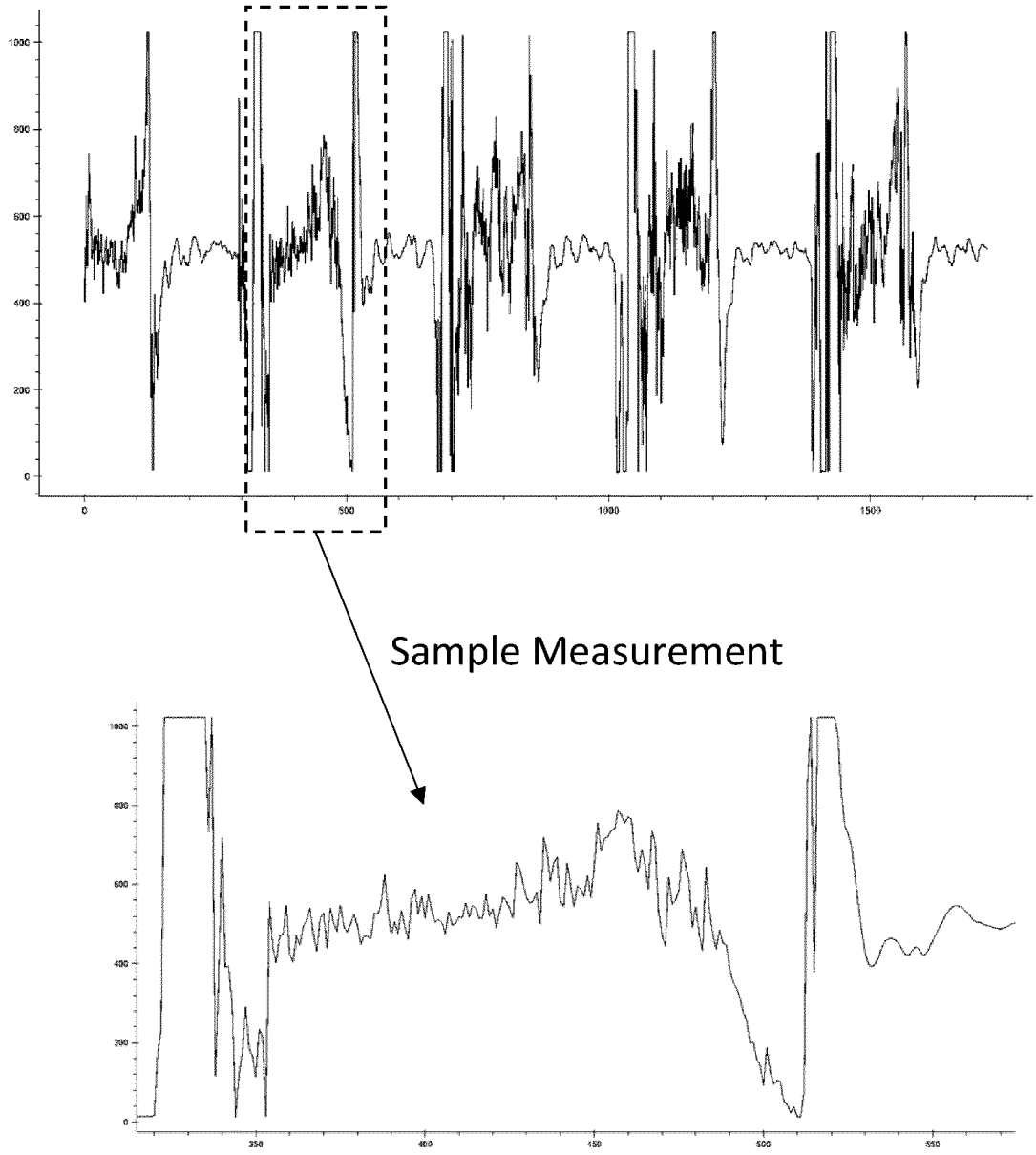


Fig. 1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800
600
400
200
0
0
500
1000
1500
Sample Measurement
1000
800
600
400
200
0
350
400
450
500
550

Fig. 2

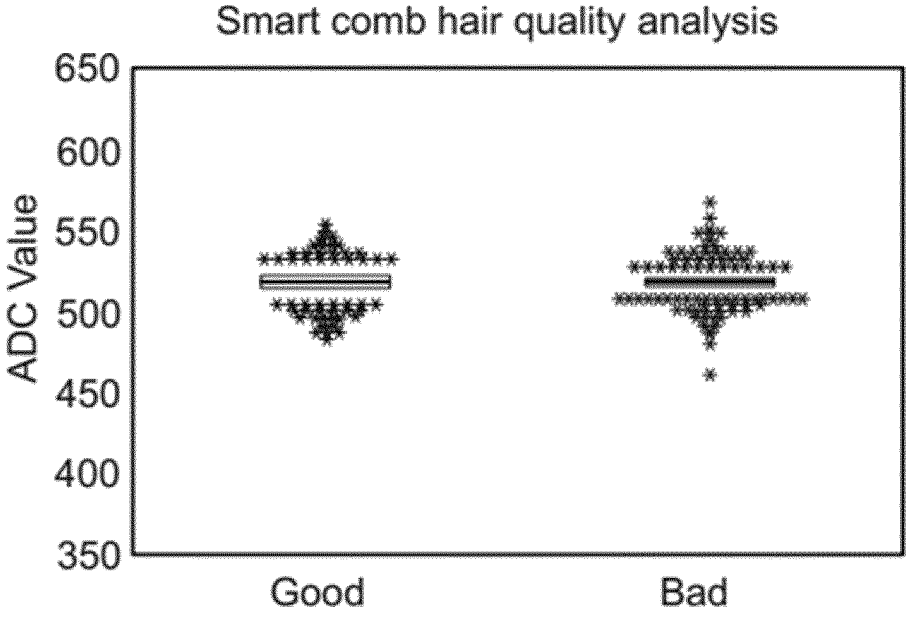
Smart comb hair quality analysis
650
600
550
500
450
400
350
ADC Value
Good
Bad

Fig. 3a

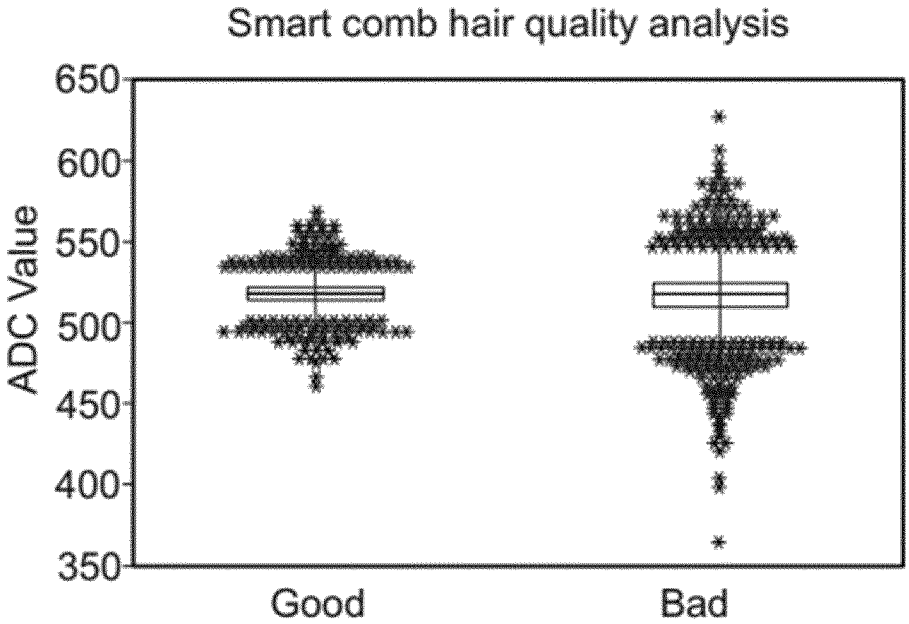
Smart comb hair quality analysis
650
600
550
500
450
400
350
ADC Value
Good
Bad

Fig. 3b

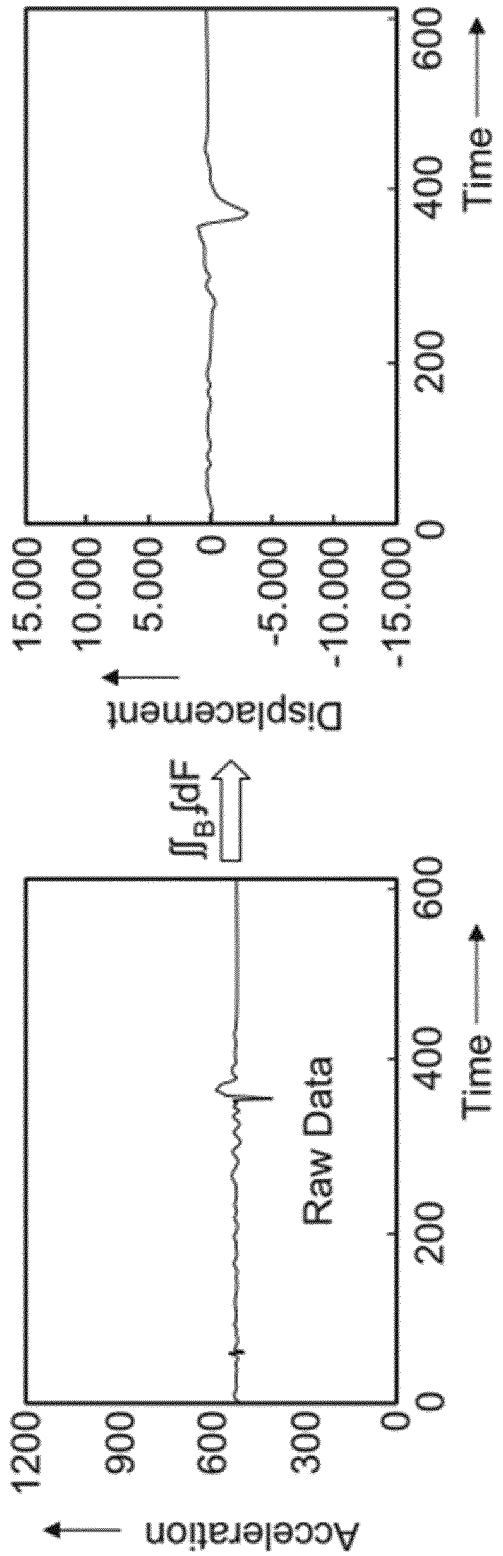
Displacement
15.000
10.000
5.000
0
-5.000
-10.000
-15.000
0
200
400
600
Time
$\iint_B \int dF$
Acceleration
1200
900
600
300
0
Raw Data
0
200
400
600
Time

Fig. 4a

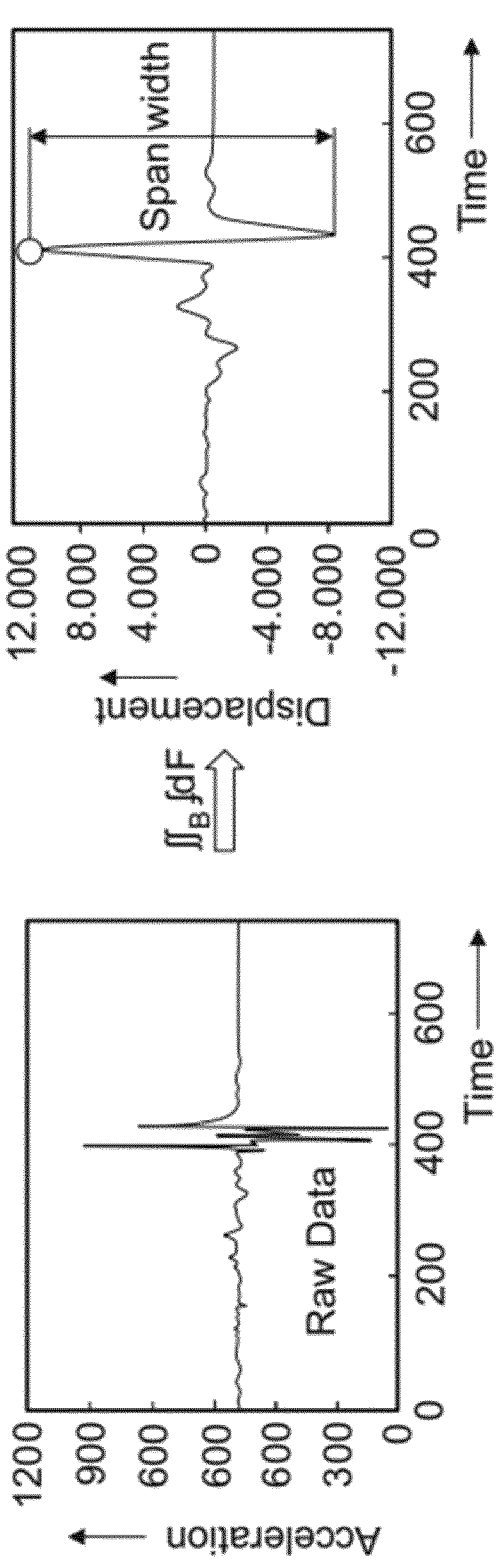
Displacement
12.000
8.000
4.000
0
-4.000
-8.000
-12.000
Span width
0
200
400
600
Time
$\iint_B \int dF$
Acceleration
1200
900
600
600
600
300
0
Raw Data
0
200
400
600
Time

Fig. 4b

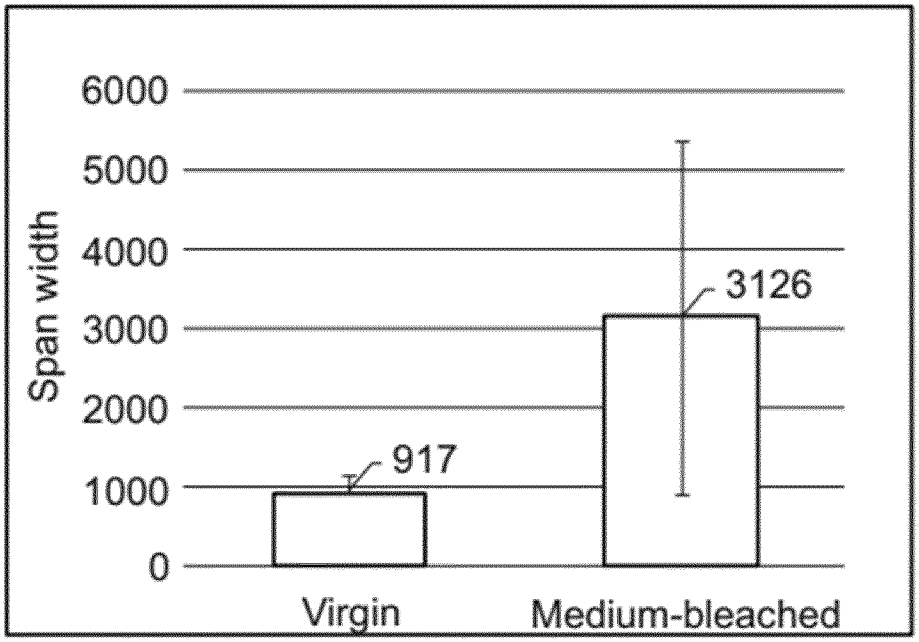
6000
5000
4000
3000
2000
1000
0
Span width
917
3126
Virgin
Medium-bleached

Fig. 4c

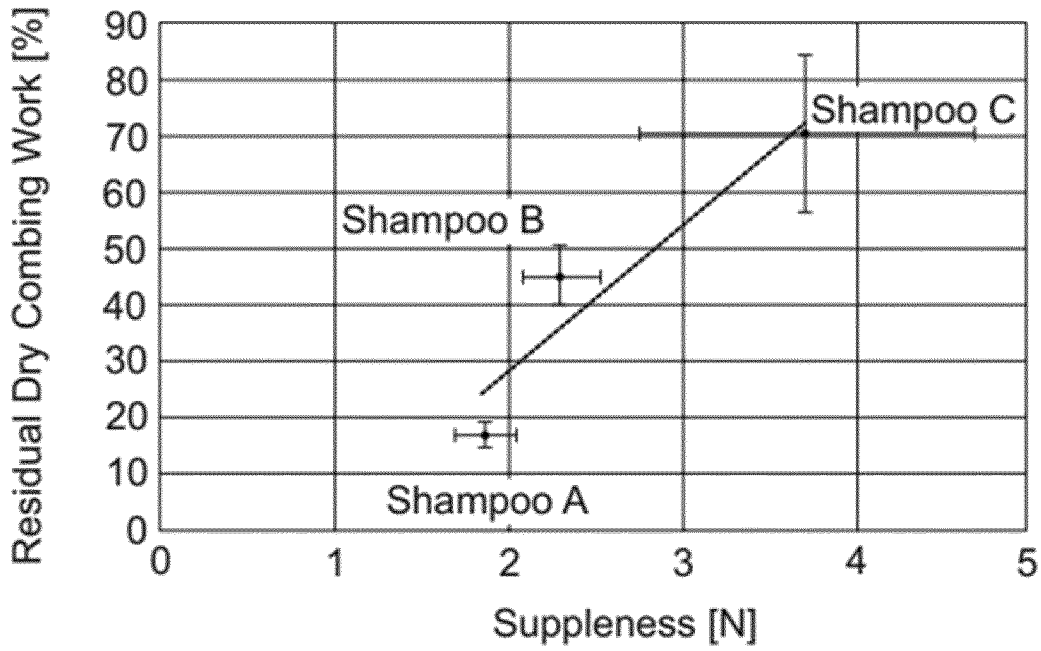
Residual Dry Combing Work [%]
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Suppleness [N]
Shampoo C
Shampoo B
Shampoo A

Fig. 5a

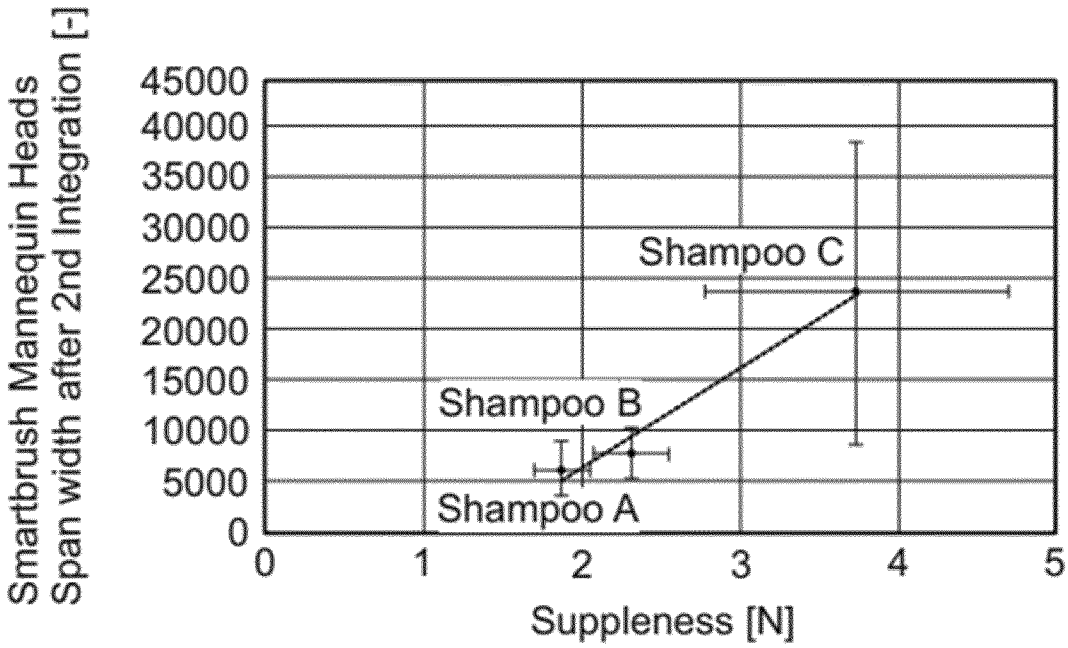
Smartbrush Mannequin Heads
Span width after 2nd Integration [-]
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
Suppleness [N]
Shampoo C
Shampoo B
Shampoo A

Fig. 5b

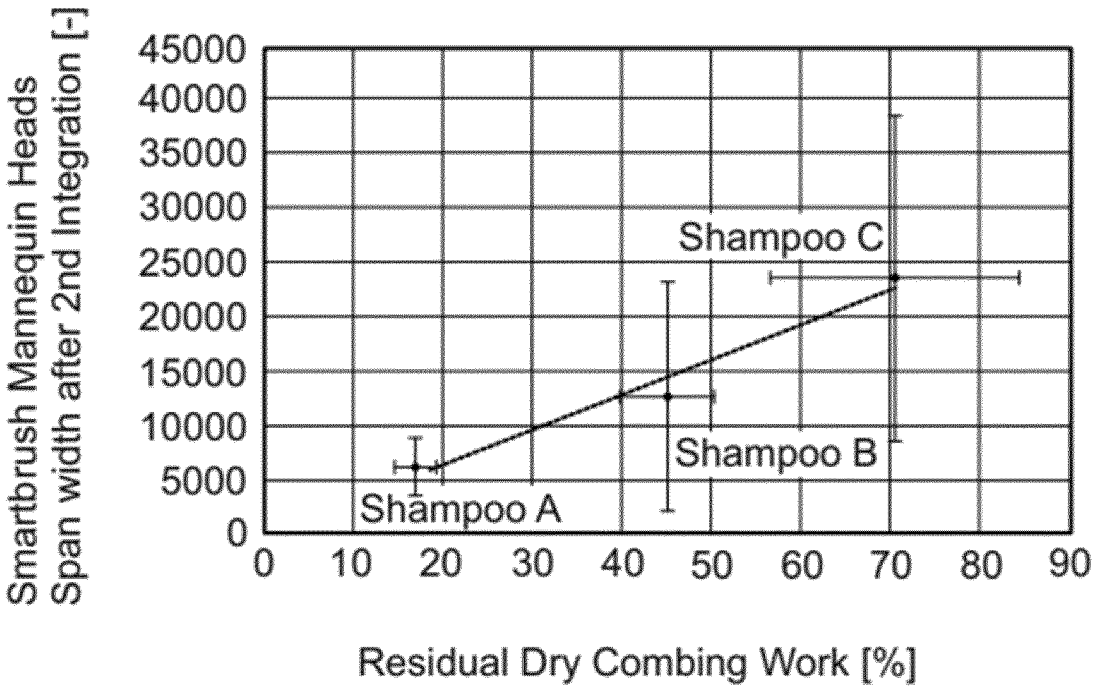
Smartbrush Mannequin Heads
Span width after 2nd Integration [-]
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
Shampoo C
Shampoo B
Shampoo A
Residual Dry Combing Work [%]

Fig. 5c

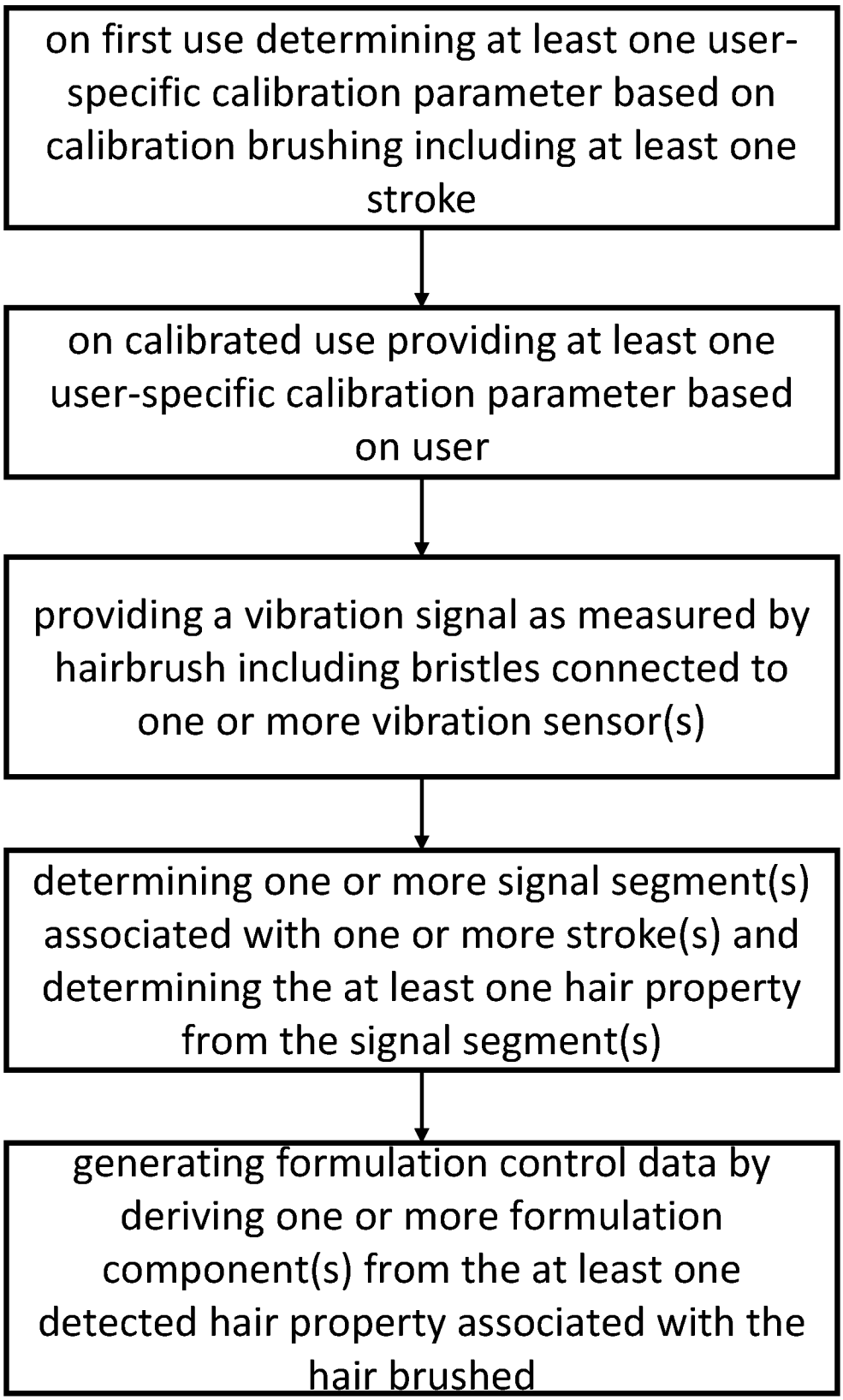
on first use determining at least one user-specific calibration parameter based on calibration brushing including at least one stroke
on calibrated use providing at least one user-specific calibration parameter based on user
providing a vibration signal as measured by hairbrush including bristles connected to one or more vibration sensor(s)
determining one or more signal segment(s) associated with one or more stroke(s) and determining the at least one hair property from the signal segment(s)
generating formulation control data by deriving one or more formulation component(s) from the at least one detected hair property associated with the hair brushed

Fig. 6

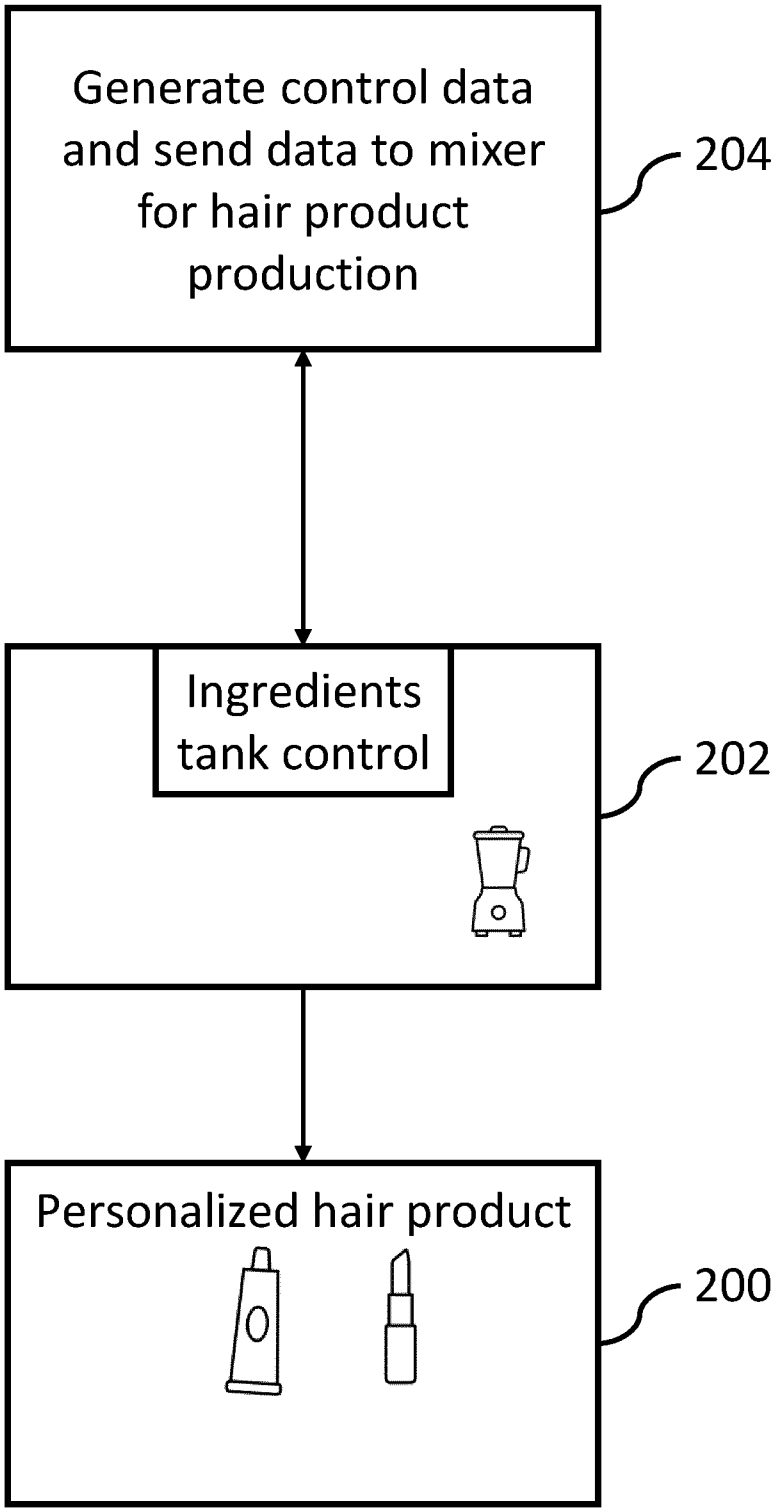
Generate control data and send data to mixer for hair product production
204
Ingredients tank control
202
Personalized hair product
200

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/065253

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61B5/00 A46B15/00 A45D44/00
ADD. A46B9/02

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)

A61D A61B A45F A45D A45B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020/221995 A1 (MATHIASZYK CARSTEN [DE] ET AL) 16 July 2020 (2020-07-16) paragraph [0002] paragraph [0015] paragraph [0017] - paragraph [0018] paragraph [0033] paragraph [0047] paragraph [0071] paragraph [0073] - paragraph [0074] paragraph [0080] paragraph [0083] - paragraph [0084] paragraph [0077] paragraph [0087] - paragraph [0088] paragraph [0095] paragraph [0131] figures 1-3	1-15

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

[x] See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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"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
21 July 2024	31/07/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Lai, Marco

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/065253

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2015/342515 A1 (HUTCHINGS CEDRIC [FR] ET AL) 3 December 2015 (2015-12-03) paragraph [0001] paragraph [0003] paragraph [0005] paragraph [0031] paragraph [0059] paragraph [0063] - paragraph [0064] paragraph [0074] - paragraph [0075] figures 1-4	1-15
X	US 2019/209078 A1 (CHARRAUD GREGOIRE [FR] ET AL) 11 July 2019 (2019-07-11) paragraph [0024] paragraph [0035] - paragraph [0038] paragraph [0043] paragraph [0052] paragraph [0055] - paragraph [0056] paragraph [0066] paragraph [0075] - paragraph [0082] paragraph [0085] - paragraph [0088] figures 1-8	1-15
A	US 2020/276546 A1 (KATZAROV JORDAN [DE] ET AL) 3 September 2020 (2020-09-03) paragraph [0004] - paragraph [0005] paragraph [0019] - paragraph [0028] paragraph [0033] paragraph [0061] paragraph [0113] - paragraph [0118] paragraph [0122] - paragraph [0125] paragraph [0191] paragraph [0248] - paragraph [0249]	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2024/065253

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP 7053627 B2	12-04-2022
		JP 2020504655 A	13-02-2020
		US 2018184796 A1	05-07-2018
		WO 2018126047 A1	05-07-2018
US 2015342515 A1	03-12-2015	EP 2945509 A1	25-11-2015
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		US 2020276546 A1	03-09-2020
		WO 2019052838 A2	21-03-2019