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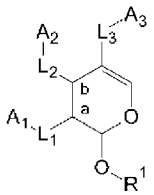
(54) Title: COMPOUNDS ATTACHABLE TO KERATINOUS TISSUES



(I)

(57) Abstract: The present disclosure relates to a hair care composition comprising a compound capable of covalently binding to hair and an excipient suitable for administration to hair, wherein the compound capable of covalently binding to hair is a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof, (I) wherein R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the hair care composition onto hair; wherein L_1, L_2 and L_3 independently from each other represent a linker group or are absent, wherein A_1, A_2 and A_3 independently from each other represent: a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or b) a C_1-C_{60} moiety or a polymeric moiety; wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b); wherein the C_1-C_{60} moiety or a polymeric moiety of group b) is: b1) configured to act as a moisturizer, a cosmetic hair coating, or a primer for attaching dyes to the hair; and/or b2) configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety; and wherein L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C- N bond in alpha-position to the carbon atom marked "a" and "b", respectively.

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COMPOUNDS ATTACHABLE TO KERATINOUS TISSUES

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims benefit from the European Patent Applications No. EP23178139.4 and No. 23178138.6, both titled: "Compounds attachable to keratinous tissues" and both filed on June 7, 2023, their content being incorporated herein by reference.

TECHNICAL FIELD

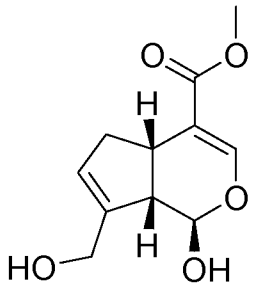
This disclosure relates to compounds which can be reliably and efficiently coupled onto keratinous tissues such as hair. More specifically, the present disclosure relates to conjugated molecules comprising an active component and specifically selected anchoring moieties which cannot form extensive conjugated π-systems once attached to the keratinous tissue. Therefore, the coupled anchoring moiety does not impart color and allows the compounds of the present disclosure to remain visually unobtrusive after being coupled onto the tissue. The disclosure also relates to topical compositions comprising these compounds and various methods and applications for these compounds.

In some embodiments, the C_1-C_{60} moiety of group b) may not comprise or be derived from salicylic acid and its derivatives. In some embodiments, the compound and/or the topical composition according to formula (I) does not comprise an ester of salicylic acid. This includes both esters formed with the hydroxy group of salicylic acid and esters formed by the carboxylic acid of salicylic acid.

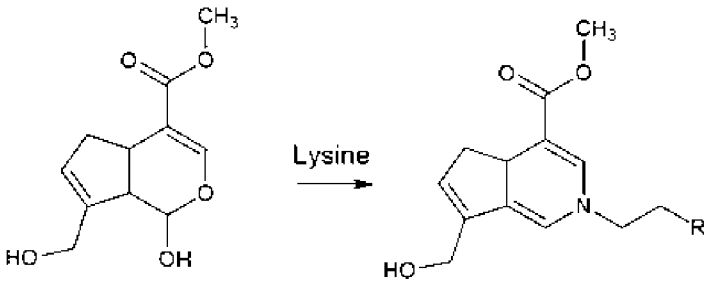
BACKGROUND

Genipin is the naturally occurring compound methyl (1R,4aS,7aS)-1-hydroxy-7-(hydroxymethyl)-1,4a,5,7a-tetrahydrocyclopenta[c]pyran-4-carboxylate (CAS RN. 6902-

77-8) and has the following structure:



Genipin can be irreversibly coupled to keratinous tissues. For instance, keratin in hair comprises lysine having aliphatic amino side chains. These amino side chains react with the cyclic hemiacetal structure of genipin according to the below representative reaction scheme:



The finally resulting coupled genipin derivative is colored intensely blue. Due to the dark blue color, genipin is commercially used a tattooing dye in semi-permanent tattoos.

This hair-coupling property makes genipin an interesting candidate to couple various active components such as moisturizers, cosmetic hair coatings, primers for attaching dyes to the hair or fragrance precursors to the hair. However, the dark blue color of genipin severely

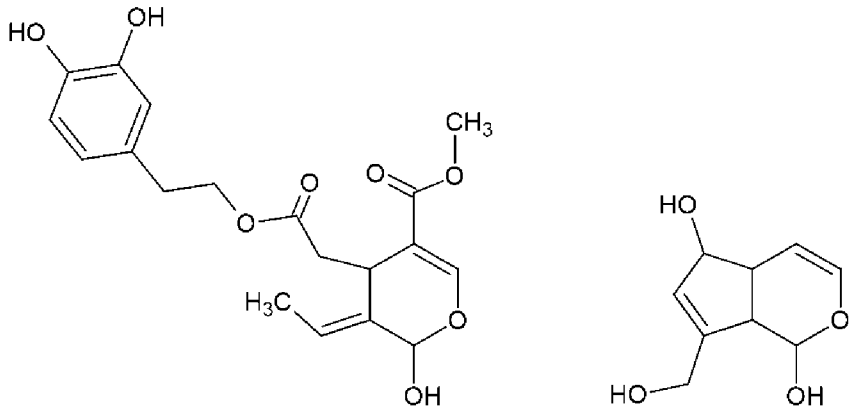
limited its utility for hair applications. Therefore, while genipin carries a number of functional groups which can be readily utilized to attach active components, it was heretofore not seriously contemplated as a means for attaching an active component to hair.

However, having compounds for unobtrusively attaching active components to hair is highly desirable.

SUMMARY

In their extensive research regarding genipin chemistry, the present inventors have come to the conclusion that a broad range of genipin derivatives can be reliably and efficiently coupled to keratinous tissues such as hair. This robust coupling chemistry can be attributed to the 3,4-dihydro-2H-pyran moiety and is largely unaffected by the further substitution of the 3,4-dihydro-2H-pyran moiety. This finding is further supported in the literature which describes that e.g. oleuropein and aucubin activated by β-glucosidase have very strong protein-denaturing, protein-crosslinking, and lysine-alkylating activities that are very

similar to, but stronger than, those of glutaraldehyde, see Konno et al., PNAS, 1999, 96 (16) 9159-9164. Deglycosylated oleuropein and aucubin have the following structures:



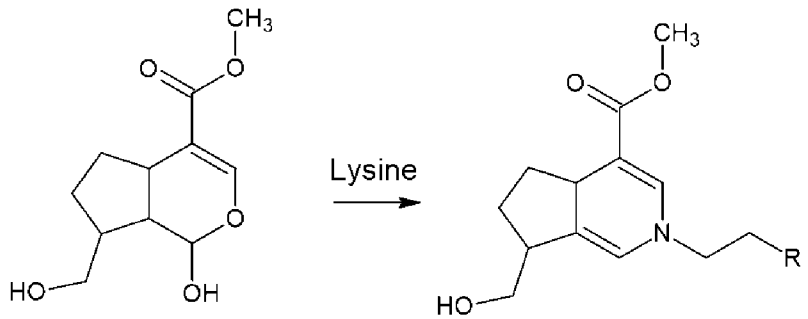
Thus, the present inventors have come to the realization that a wide variety of 3,4-dihydro-2H-pyran derivatives can effectively and irreversible couple to hair.

Indeed, initial trials of the present inventors with white sheep wool have demonstrated the feasibility of coupling genipin and its derivatives to hair.

Surprisingly, the color imparted to the sheep wool was very homogenously distributed which suggests that the molecules uniformly cover the hair surface. This suggests that any attached active component will also be distributed in a very uniform coating. This will be

beneficial for many applications, in particular in the anchoring of moisturizers, cosmetic hair coatings and primers for attaching dyes to the hair.

Moreover, in their research, the present inventors have surprisingly found that hydrogenated genipin derivatives remain substantially colorless after being reacted with lysine. A representative example is shown in the below reaction scheme:



hydrogenated genipin colorless

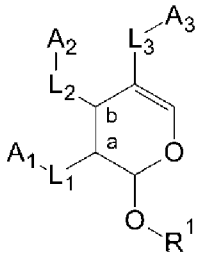
The colorless (or nearly colorless and, thus, not visually perceivable on the hair) state of coupled hydrogenated genipin derivative can be explained by the fact that the 1,4-dihydropyridine moiety formed with lysine is not endowed with a conjugated π-electron system with the double bond that is present in the cyclopentene-moiety of genipin (and absent in hydrogenated genipin).

The present inventors have thus come to the conclusion that a large variety of 3,4-dihydro-2H-pyran derivatives will unobtrusively bind to hair as long as the 3,4-dihydro-2H-pyran derivatives are selected such that formation of a conjugated π-electron system to the hair-bound 1,4-dihydropyridine moiety is avoided. 3,4-Dihydro-2H-pyran derivatives meeting this requirement are, thus, particularly useful as a visually non-perceivable anchoring moiety to efficiently, irreversibly and unobtrusively couple active ingredients to hair.

Finally, the active ingredient may be stably bound to the 3,4-dihydro-2H-pyran derivative or it may be bound to the 3,4-dihydro-2H-pyran derivative such that it is released over

time, e.g. by hydrolysis or enzymatic cleavage (provided by endogenous enzymes and/or exogenous microbial enzymes) of a functional group linking the active ingredient to the 3,4-dihydro-2H-pyran derivative. Suitable functional groups providing sustained release properties are well-known in the art and readily available to the skilled person, see for instance V. Redasani, and S. Bariwidely, Prodrug Design - Perspectives, Approaches and Applications in Medicinal Chemistry, 1st ed., 2015, ISBN: 9780128035191, which is incorporated herein in its entirety by reference thereto.

Accordingly, in a first aspect, the present disclosure relates to a hair care composition comprising a compound capable of covalently binding to hair and an excipient suitable for administration to hair, wherein the compound capable of covalently binding to hair is a compound of formula (I),



(I).

In the compound of formula (I), R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the topical composition onto hair. L_1, L_2 and L_3 independently from each other represent a linker group or are absent. A_1, A_2 and A_3 independently from each other represent a moiety of:

group a): a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen; or

group b): a C_1-C_{60} moiety or a polymeric moiety.

The C_1-C_{60} moiety or polymeric moiety of group b) is carrying the active ingredient/component. Accordingly, at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b).

The C_1-C_{60} moiety or polymeric moiety of group b) is subdivided into two sub-groups b1) and b2).

The C_1-C_{60} moiety or polymeric moiety according to group b1) is configured to act as moisturizer, a cosmetic hair coating, or a primer for attaching dyes to the hair.

In other words, this means – here and for all other aspects of the present disclosure – that the C_1-C_{60} moiety or polymeric moiety of group b1) is a moisturizing moiety, a moiety providing a cosmetic coating to the hair, or a moiety for priming the hair for the attachment of dyes to the hair, while being attached to the remainder of the 3,4-dihydro-2H-pyran moiety.

Additionally or alternatively, this means – here and for all other aspects of the present disclosure – that the C_1-C_{60} moiety or polymeric moiety of group b1) is a moisturizer, a cosmetic hair coating agent, or a primer for attaching dyes to the hair.

Additionally or alternatively, this means – here and for all other aspects of the present disclosure – that the C_1-C_{60} moiety or polymeric moiety of group b1) is a moisturizer, a cosmetic hair coating agent, or a primer for attaching dyes to the hair, which is attached to the remainder of the 3,4-dihydro-2H-pyran moiety.

The C_1-C_{60} moiety or polymeric moiety according to group b2) is configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

In other words, this means – here and for all other aspects of the present disclosure – that the C_1-C_{60} moiety or polymeric moiety of group b2) is providing its moisturizing activity, its cosmetic hair coating effect or its olfactory effect after being cleaved off or released from the remainder of the 3,4-dihydro-2H-pyran moiety.

Additionally or alternatively, this means – here and for all other aspects of the present disclosure – that the C_1-C_{60} moiety or polymeric moiety of group b1) is a moisturizer, a cosmetic hair coating agent, or a fragrance after being cleaved off or released from the remainder of the 3,4-dihydro-2H-pyran moiety.

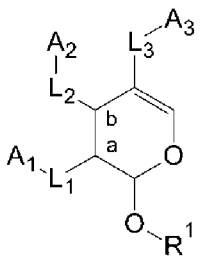
Additionally or alternatively, this means – here and for all other aspects of the present disclosure – that the C_1-C_{60} moiety or polymeric moiety of group b1) is a moisturizer, a cosmetic hair coating agent, or a fragrance which can be cleaved off or released from the remainder of the 3,4-dihydro-2H-pyran moiety after the compound has covalently bound to the hair.

While in some cases, for instance in case of a fragrance, the attached active ingredient is only active after being released, the two subgroups b1) and b2) are not necessarily mutually exclusive. For instance, a polyol humectant may provide its activity while being attached to the 3,4-dihydro-2H-pyran moiety but also when it is released from the 3,4-dihydro-2H-pyran moiety.

As indicated above, the 3,4-dihydro-2H-pyran derivatives of the present disclosure are selected such that the formation of a conjugated π-electron system to the bound 1,4-dihydropyridine moiety is essentially avoided. Accordingly, the compounds of the present disclosure are restricted such that L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively.

The compound of the above formula may also be present as its tautomer and/or as a pharmaceutically acceptable salt.

In a second aspect, the present disclosure relates to the use of a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b)

the C_1-C_{60} moiety or the polymeric moiety of group b) is

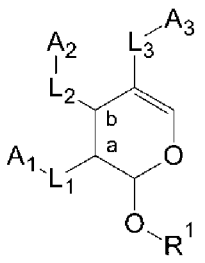
b1) configured to act as a moisturizer or a cosmetic hair coating; and/or

b2) configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety; and

L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively;

for providing a cosmetic effect to hair, more specifically to provide a moisturizing effect, a conditioning effect, a gloss effect, an anti-frizz effect, and/or an olfactory effect to hair.

In a third aspect, the present disclosure relates to a method of coloring hair, the method comprising applying a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof, to hair;



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a primer for attaching dyes to the hair; and

L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively;

followed by contacting the primed hair with a dye, a pigment, a precursor of a dye, or a precursor of a pigment to effect a covalent attachment of a dye or a pigment to hair.

Any of the specific compounds which are disclosed for the first aspect of the present disclosure and which are directed to a primer for attaching dyes to the hair also represent specific embodiments according to this aspect of the present disclosure.

In a fourth aspect, the present disclosure specifically relates to the compounds of the present disclosure per se, i.e. independent from the topical composition.

DESCRIPTION OF DRAWINGS

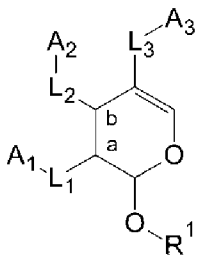
Fig. 1 shows a reaction scheme for the synthesis of a compound of the present disclosure comprising erythritol as active component.

Figs. 2 to 6 show UV spectra of compounds comprising a 3,4-dihydro-2H-pyran moiety (some of which being compounds according to the present disclosure) and the UV spectra of their corresponding lysine conjugates.

Fig. 7 shows the attachment of compounds of the present disclosure to pig skin.

DETAILED DESCRIPTION

In a first aspect, the present disclosure relates to a compound capable of covalently binding to hair, in particular to said compound being comprised in a hair care composition further comprising an excipient suitable for topical administration, wherein the compound capable of covalently binding to hair is a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I).

The term "compound capable of covalently binding to hair" is applied its common meaning in the art and in particular refers to a compound which can undergo a chemical reaction which covalently binds it to amino side-chains of amino acids such as lysine. Additionally

or alternatively, a compound is "capable of covalently binding to hair" if the compound (or a topical composition containing the compound) cannot be comprehensively washed off from (explanted) (human) hair by water, soap, and/or isopropanol after incubating the compound (or the topical composition comprising the compound) on the (human) hair at 37°C for 24 hours. Additionally or alternatively, a compound is "capable of covalently binding to hair" if, when placing 0.1 mol/L of the compound in an aqueous solution having a pH of about 5 and further containing 0.1 mol/L lysine at 37°C for 24 hours, the compound is converted by more than 10 mol% to its corresponding 1,4-dihydropyridine derivative.

Although the feature in the aforementioned paragraph explicitly refers to "hair", the term "hair care composition" is not to be construed as excluding compositions also (or primarily or even exclusively) formulated/intended for other skin appendages. Such other skin appendages are nails, sweat glands, and sebaceous glands. However, hair is the preferred embodiment.

In the compound of formula (I), R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the topical composition onto hair. When referring in this context to "physiological conditions" it should be understood that this in particular refers to the pH conditions encountered at the locus where the compound of formula (I) is supposed to bind to in the subject to be treated (hair or skin appendages). Additionally or alternatively, the term "protective groups hydrolysable under physiological conditions after application of the topical composition" refers to a group which is hydrolysed when placing 0.1 mol/L of the compound of formula (I) in an aqueous solution having a pH of about 5 for 24 hours, wherein the group in question qualifies as "protective group hydrolysable under physiological conditions after application of the topical composition" if more than 10 mol% is converted to its corresponding hemiacetal.

A_1, A_2 and A_3 independently from each other represent a moiety of:

group a): a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

group b): a C_1-C_{60} moiety or a polymeric moiety.

The C_1-C_{60} moiety or the polymeric moiety of group b) is carrying the active ingredient/component. Accordingly, at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b).

The C_1-C_{60} moiety or the polymeric moiety of group b) is subdivided into two sub-groups b1) and b2). The C_1-C_{60} moiety or the polymeric moiety according to group b1) is configured to act as a moisturizer, a cosmetic hair coating or a primer for attaching dyes to the hair. In other words, the active ingredient/component is capable of providing its activity while being attached to the remainder of the 3,4-dihydro-2H-pyran moiety. The C_1-C_{60} moiety or the polymeric moiety according to group b2) is configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety. In other words, the active ingredient/component is capable of providing its activity after being released from the remainder of the 3,4-dihydro-2H-pyran moiety. While in some cases, for instance in case of a fragrance, the attached active ingredient is only active after being released, the two subgroups b1) and b2) are not necessarily mutually exclusive. For instance, a polyol humectant may provide its moisturizing activity while being attached to the 3,4-dihydro-2H-pyran moiety but also when it is released from the 3,4-dihydro-2H-pyran moiety.

When referring to the C_1-C_{60} moiety according to group b2) being cleaved off of the 3,4-dihydro-2H-pyran moiety, it should be understood that this refers to the 3,4-dihydro-2H-pyran moiety which includes (or at least partially includes) L_1, L_2 and/or L_3 (if present) as well as any remaining A_1 to A_3 moieties. Furthermore, it should be understood that this refers to a cleavage under physiological conditions encountered by the compound after application of the topical composition onto hair (or skin appendages). When referring in this context to “physiological conditions” it should be understood that this in particular refers to the ambient conditions, in particular pH, enzymatic and temperature conditions, encountered at the locus where the compound of formula (I) is supposed to bind to keratinous tissues in e.g. the hair of the (mammalian, in particular human) subject to be treated.

As indicated above, the 3,4-dihydro-2H-pyran derivatives of the present disclosure are selected such that the formation of a conjugated π-electron system to the bound 1,4-dihydropyridine moiety is essentially avoided. Accordingly, the compounds of the present disclosure are restricted such that L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked "a" and "b", respectively.

A_1, A_2 and A_3 may independently from each other represent a C_1-C_{30} moiety, i.e. be a moiety according to group a). The term is not particularly limited beyond its common understanding in the art and refers to any moiety comprising between 1 and 30 carbon atoms. The presence of further heteroatoms, i.e. atoms not being C, is not excluded, i.e. atoms such a H, O, and N may be contained in the moiety.

A_1, A_2 and A_3 may independently from each other represent a C_1-C_{60} moiety or a polymeric moiety according to group b1) and/or b2). Again, the term C_1-C_{60} moiety is not particularly limited beyond its common understanding in the art and refers to any moiety comprising between 1 and 60 carbon atoms. The presence of further heteroatoms, i.e. atoms not being C, is not excluded, i.e. atoms such a H, O, and N and others may be contained in the C_1-C_{60} moiety. Also the term "polymeric moiety" is not particularly limited beyond its common understanding in the art and refers to any oligomeric (herein defined as more than 3 and up to 8 repeat units) or polymeric moiety (herein defined as having more than 8 repeat units). The polymer will typically comprise carbon and/or silicon, but the presence of further heteroatoms, i.e. atoms not being C or Si, is not excluded, i.e. atoms such a H, O, N and others may be contained in the polymeric moiety.

A_1, A_2 and A_3 may independently from each other represent a C_1-C_{60} moiety or a polymeric moiety of group b1) configured to act as moisturizer, a cosmetic hair coating, or a primer for attaching dyes to the hair. Said functional language is meant to imply that the C_1-C_{60} moiety or the polymeric moiety (or more specifically the compound in its entirety after being covalently bound to keratinous material such as hair) is capable of providing the

referenced effect (a moisturizing effect, providing a coating for providing a cosmetic effect, providing a primer allowing attachment of dyes to the hair).

A_1, A_2 and A_3 may independently from each other also represent a C_1-C_{60} moiety or a polymeric moiety of group b2) which is configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety. Said functional language is meant to imply that the compound released from the C_1-C_{60} moiety or the polymeric moiety (or more specifically from the compound/polymer in its entirety after being covalently bound to keratinous material such as hair) is capable of providing the referenced effect (a moisturizing effect, providing a coating for providing a cosmetic effect or an olfactory effect) after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

In some embodiments, A_1, A_2 and A_3 may independently from each other represent a polymeric moiety of group b1) which is configured to act as a moisturizer or as a cosmetic hair coating. Said functional language is meant to imply that the polymeric moiety (or more specifically the compound in its entirety after being covalently bound to keratinous material such as hair) is capable of providing the moisturizing effect or a cosmetic effect.

The term “moisturizer” refers to a compound/moiety which is capable of directly binding water (via hydrogen bonding) in the hair or of reducing evaporation of water from the hair. Accordingly, the term encompasses moisturizers, emollients and occlusives as these terms are used and understood in the art.

The term “cosmetic hair coating” refers to a compound/moiety which is capable of providing a coating onto hair which provides a cosmetic benefit to the subject. Accordingly, the term encompasses coatings imparting a hair conditioning effect, gloss or shine, an anti-frizz effect, or a reinforcing (styling) effect. For the purposes of the present disclosure, a coloring effect/benefit is not encompassed by the term “cosmetic hair coating”, i.e. a dye moiety is not a moiety of group b1) and/or group b2). Specifically, the C_1-C_{60} moiety of group b) is not a color-imparting moiety, in particular not a color-

imparting moiety having at least one absorption peak within the wavelength range of 380 to 790 nm.

The term "primer for attaching dyes to the hair" refers to a compound/moiety which is capable of providing a site for anchoring dyes, pigments and/or compounds which can be developed into dyes or pigments on the hair. Said anchoring is preferably covalent anchoring, i.e. the primer is able to react with dyes, pigments and/or compounds which can be developed into dyes or pigments by forming a covalent bond.

In other words, term "primer for attaching dyes to the hair" refers to a compound/moiety comprising a functional group for coupling dyes, pigments and/or compounds which can be developed into dyes or pigments on the hair, to the hair. Said coupling is preferably covalent anchoring.

The term "fragrance" refers to the common meaning in the art and in particular refers to a volatile compound which is capable of providing an olfactory impression, in particular an olfactory impression comprising one or more of the seven fundamental odors (floral, fruity, minty, nutty, pungent, sweet, and woody).

L_1, L_2 and L_3 independently from each other represent a linker group or are absent. The term "linker group" is not particularly limited and refers to any chemical group which covalently connects the 3,4-dihydro-2H-pyran moiety to the corresponding moiety A_1, A_2 and A_3 moiety, respectively. For the sake of clarity, it should be understood that L_1 and L_2 connect to the 3,4-dihydro-2H-pyran moiety by a single bond, i.e. ring positions marked with "a" and "b" represent methines ("CHR_3").

In some embodiments, L_1, L_2 and L_3 may, if present and independently from each other, represent optionally substituted hydrocarbon moieties each comprising, in combination with their optional substituents, 1 to 14 carbon atoms. In some embodiments, L_1 and L_2 may, if present and independently from each other, represent optionally substituted

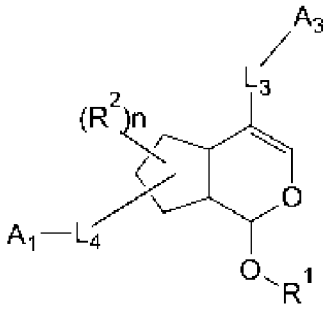
hydrocarbon moieties each comprising, in combination with their optional substituents, 1 to 14 carbon atoms.

In some embodiments, L_1, L_2 and L_3 may also form optionally substituted cyclic structures. In some embodiments, L_1 and L_2 are present and form a 5-, 6-, 7- or 8-membered ring, in particular a cyclopentyl, a cyclohexyl, a pyrrolidinyl, a piperidinyl, a tetrahydrofuranyl or a tetrahydropyranyl.

In some embodiments, L_1 and L_2 form an optionally substituted 5- or 6-membered ring and comprise, together with their substituents, 2 to 14 carbon atoms, more specifically 3 to 12, and in particular 4 to 8 carbon atoms. For the sake of clarity, it should be understood that when L_1 and L_2 form a 5- or 6-membered, two of the ring carbons derive from the 3,4-dihydro-2H-pyran moiety and are therefore not counted toward the total carbon number of L_1 and L_2. To give two examples: If L_1 and L_2 form a tetrahydrofuranyl, the number of carbon atoms is 2. If L_1 and L_2 form a cyclopentyl which is monosubstituted with a $-CH_2-OH$ group, the number of carbon atoms is 4.

In some embodiments, it may be particularly advantageous that L_1 and L_2 are present and form an optionally substituted 5-or 6-membered ring, in particular cyclopentyl or cyclohexyl, to which A_1 and A_2 are attached, optionally via a group selected from: -O-, -S-, -C(O)-, $-CO_2-$, -O-C(O)-, -NH-C(O)-, -C(O)-NH-, $-(CH_2)_{1-4}-$, $-(CH_2)_{1-4}-O-$ and $-O-(CH_2)_{1-4}-$, or combinations thereof. In some embodiments, it may be most advantageous that L_1 and L_2 are present and form a cyclopentyl, a cyclopentenyl, a cyclohexyl, or a cyclohexenyl ring to which A_1 and A_2 are attached, optionally via a group selected from: -O-, -S-, -C(O)-, $-CO_2-$, -O-C(O)-, -NH-C(O)-, -C(O)-NH-, $-(CH_2)_{1-4}-$, $-(CH_2)_{1-4}-O-$ and $-O-(CH_2)_{1-4}-$ or combinations thereof.

In some embodiments, the compound capable for covalently binding to hair is a compound of formula (II), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(II);

wherein R^1, L_3, A_1 and A_3 are as defined for the compound of formula (I);

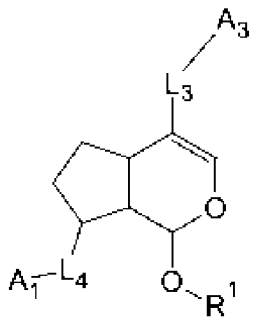
wherein $(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;

wherein n is an integer selected from 1 and 2; and

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$- or combinations thereof; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

In some embodiments, the compound capable for covalently binding to hair is a compound of formula (III), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(III);

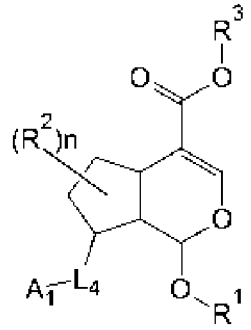
wherein R^1, L_3, A_1 and A_3 are as defined for the compound of formula (I); and

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -

NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$- or combinations thereof; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

In some embodiments, the compound capable for covalently binding to hair is a compound of formula (IV), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(IV);

wherein R^1 and A_1 are as defined for the compound of formula (I);

wherein $(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;

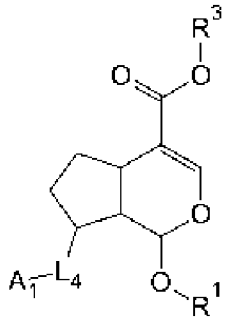
wherein n is an integer selected from 1 and 2;

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$- or combinations thereof;

wherein R^3 represents hydrogen or an optionally substituted hydrocarbon moiety comprising, in combination with their optional substituents, 1 to 14 carbon atoms; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

In some embodiments, the compound capable for covalently binding to hair is a compound of formula (V), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(V);

wherein R^1 and A_1 are as defined for the compound of formula (I);

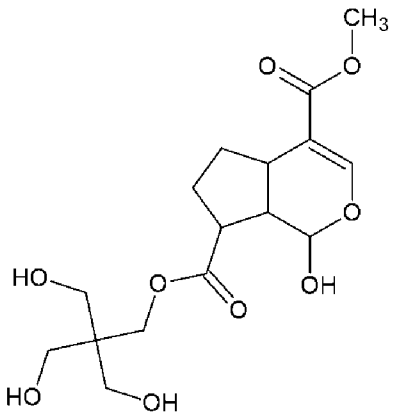
wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$- or combinations thereof;

wherein R^3 represents hydrogen or an optionally substituted hydrocarbon moiety comprising, in combination with their optional substituents, 1 to 14 carbon atoms; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

The usefulness of the compounds of the present disclosure will be exemplarily illustrated by the following example. Of course, other applications will be readily apparent and routinely available to the skilled person on the basis of the guidance given in the present disclosure.

The example concerns a compound intended to provide a moisturizing effect. Moisturizers are well-established in cosmetics and include a large variety of compounds capable of binding water in hair. Examples include polyols such as glycerol, pentaerythritol and sorbitol but also other hydrogen-bonding compounds such as urea. A compound according to the present disclosure carrying a pentaerythritol as the C_1-C_{60} moiety of group b) is shown below:



Due to the large number of hydroxyl groups, the above compound according to the present disclosure can be expected to provide a long-lasting moisturizing effect to the hair. The moisturizing effect will be given even if the pentaerythritol moiety is still attached to the hair via the 3,4-dihydro-2H-pyran moiety. As such, the moiety is an example of group b1). In addition, the ester group linking the pentaerythritol moiety to the remainder of the compound is cleavable by (microbial) esterases which are abundantly found on the hair. Therefore, it is also an example of a moiety which at the same time belongs to group b2). If it is desirable that the pentaerythritol moiety belongs to only group b1) another functional group may be selected. For instance, replacing the ester linkage by an ether linkage may be contemplated.

An outline of the chemical synthesis of the above compound is shown in Fig. 1. The synthesis of compounds (1) and (2) is disclosed in the co-pending international application WO 2023/102652 A1). (2) can be converted to the corresponding acylchloride by thionylchloride which then can be coupled with pentaerythritol to yield ester (3). Ester (3) can be hydrolysed in an acidic aqueous solution with mild heating to yield the target compound (4).

Further aspects, features and embodiments of the present disclosure will be discussed in the following.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety of group b) may comprise a functional group which couples the C_1-C_{60} moiety or the polymeric moiety to the corresponding L_1, L_2 or L_3 moiety or, if the corresponding L_1, L_2 or L_3 moiety is absent, to the 3,4-dihydro-2H-pyran moiety.

In some embodiments, the functional group may comprise a carbon atom, an oxygen atom, a nitrogen atom, a sulfur atom, a phosphorus atom, or a combination thereof; more specifically a carbon atom, an oxygen atom, a nitrogen atom, or a combination thereof; and in particular a carbon atom and/or an oxygen atom.

In some embodiments, the functional group may comprise one or more of, two or more of, three or more of, four or more of, or all of: 1 and 12 carbon atoms, more specifically between 1 and 6 carbon atoms, and in particular between 1 and 3 carbon atoms; 1 and 12 oxygen atoms, more specifically between 1 and 6 oxygen atoms, and in particular between 1 and 3 oxygen atoms; 1 and 4 nitrogen atoms, more specifically between 1 and 3 nitrogen atoms, and in particular between 1 and 2 nitrogen atoms; 1 and 3 sulfur atoms, more specifically between 1 and 2 sulfur atoms, and in particular 1 sulfur atom; 1 and 3 phosphorus atoms, more specifically between 1 and 2 phosphorus atoms, and in particular 1 phosphorus atom.

In some embodiments, the functional group may be cleavable under physiological conditions after application of the topical composition onto hair. When referring in this context to “physiological conditions” it should be understood that this in particular refers to the pH conditions encountered at the locus where the compound of formula (I) is supposed to bind to keratinous tissues in hair of the (mammalian, in particular human) subject to be treated. In some embodiments, the functional group may be hydrolysable at the physiological pH of mammal hair, more specifically of human hair, and in particular at a pH of between about 4 to about 6. A suitable *in-vitro* test is placing 0.1 mol/L of the compound of formula (I) in aqueous solution having a pH of about 5 at 37°C for 24 hours, wherein the group in question qualifies as hydrolysable if a notable amount of the group is hydrolysed (e.g. more than 5 mol%, or more than 10 mol%).

In some embodiments, the functional group may be enzymatically cleavable under physiological conditions after application of the topical composition onto hair, in particular enzymatically cleavable by enzymes present on the human hair. When referring in this context to "physiological conditions" it should be understood that this in particular refers to the conditions encountered at the locus where the compound of formula (I) is supposed to bind to keratinous tissues in hair of the (mammalian, in particular human) subject to be treated. A suitable *in-vitro* test is placing 0.1 mol/L of the compound of formula (I) in aqueous solution having a pH of about 5 at 37°C for 24 hours and further containing 50 U of esterase activity, wherein the group in question qualifies as enzymatically cleavable if a notable amount of the group is cleaved (e.g. more than 5 mol-%, or more than 10 mol-%).

In some embodiments, the functional group may be configured to be cleaved to a hydroxyl group, a primary or secondary amine group, a carboxylic acid, a thiol, an aldehyde, a ketone, a thiocarbonic acid, a sulfonic acid, a sulfinic acid, a phosphoric acid, a phosphonic acid, an olefin or an oxime; or salts thereof.

In some embodiments, the functional group may be configured to provide a hydroxyl group, a primary or secondary amine group, a carboxylic acid, a thiol, an aldehyde, a ketone, a thiocarbonic acid, a sulfonic acid, a sulfinic acid, a phosphoric acid, a phosphonic acid, an olefin, or an oxime; or salts thereof; on the corresponding L_1, L_2 or L_3 moiety which is attached to the C_1-C_{60} moiety or the polymeric moiety of group b) or, if the corresponding L_1, L_2 or L_3 moiety is absent, on the 3,4-dihydro-2H-pyran moiety after cleaving.

In some embodiments, the functional group may be configured to provide a hydroxyl group, a primary or secondary amine group, a carboxylic acid, a thiol, an aldehyde, a ketone, a thiocarbonic acid, a sulfonic acid, a sulfinic acid, a phosphoric acid, a phosphonic acid, an olefin, or an oxime; or salts thereof; on the C_1-C_{60} moiety or the polymeric moiety of group b) after cleaving.

In some embodiments, the functional group may comprise a carbon ester, in particular a monoester, 1,1-diester, a carbonate, or a carbamate; an ether or thioether, in particular an acetal, a hemi-acetal, a glycosidic group or a thioacetal; an carbon amide, in particular a peptide or a N-Mannich base; an enol; an enamine; an imine; an oxime; a sulfate ester; a sulfonic acid ester; a sulfonic acid amid; a phosphoric acid ester; a phosphonic acid ester; a phosphoric acid amide; or a phosphonic acid amide.

In some embodiments, the functional group may be a functional group mentioned in chapter 6 of the textbook Prodrug Design Perspectives, Approaches and Applications in Medicinal Chemistry, 1st ed., 2015, ISBN: 9780128035191, which is incorporated herein (for the aforementioned purpose and in its entirety) by reference thereto.

In some embodiments, A_1 may represent the C_1-C_{60} moiety or the polymeric moiety of group b). Additionally or alternatively, A_2 may represent a C_1-C_{60} moiety or the polymeric moiety of group b). Additionally or alternatively, A_3 may represent a C_1-C_{60} moiety or the polymeric moiety of group b). Additionally or alternatively, the remainder of A_1, A_2 and A_3 may represent a substituent of group a), more specifically a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen.

In some embodiments, L_1 may be present and represent an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms. Alternatively or additionally, in some embodiments, L_2 may be present and represent an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms. Alternatively or additionally, in some embodiments, L_3 may be present and represent an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms.

In some embodiments, L_1 may be present and represent an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms and the functional group may be attached to L_1. Alternatively or additionally, in some embodiments, L_2 may be present and represent an optionally substituted

hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms and the functional group may be attached to L_2. Alternatively or additionally, in some embodiments, L_3 may be present and represent an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms and the functional group may be attached to L_3. In some embodiments, when any of L_1 to L_3 are (also) optionally substituted with heteroatoms, the respective linker group may comprise 1 to 8, more specifically 1 to 6, and in particular 1 to 4 oxygen atoms; 1 to 8, more specifically 1 to 6, and in particular 1 to 4 nitrogen atoms; 1 to 6, more specifically 1 to 4, and in particular 1 to 3 sulfur atoms; 1 to 6, more specifically 1 to 4, and in particular 1 to 3 phosphorus atoms, and 1 to 10, more specifically 1 to 8, and in particular 1 to 6 halogen atoms. In some embodiments, said respective linker group does not contain any further atoms species besides carbon, the (optional) aforementioned atom species and hydrogen.

In some embodiments, L_1 and L_2 may be present and form an optionally substituted 5-or 6-membered ring, in particular cyclopentyl or cyclohexyl, to which A_1 and A_2 may be attached, optionally via a group selected from: -O-, -S-, -C(O)-, $-CO_2-$, -O-C(O)-, -NH-C(O)-, -C(O)-NH-, $-(CH_2)_{1-4}-$, $-(CH_2)_{1-4}-O-$ and $-O-(CH_2)_{1-4}-$, or combinations thereof. It should be understood that the aforementioned specific groups may be part of a larger functional group, hence the reference to “combinations thereof”. As an example, a carbamate may be considered as both -O- and -C(O)-NH- or a combination thereof.

In some embodiments, L_1 and L_2 may be present and form a cyclopentyl, a cyclopentenyl, a cyclohexyl, or a cyclohexenyl ring to which A_1 and A_2 may be attached, optionally via a group selected from: -O-, -S-, -C(O)-, $-CO_2-$, -O-C(O)-, -NH-C(O)-, -C(O)-NH-, $-(CH_2)_{1-4}-$, $-(CH_2)_{1-4}-O-$ and $-O-(CH_2)_{1-4}-$, or combinations thereof. It should be understood that the aforementioned specific groups may be part of a larger functional group, hence the reference to “combinations thereof”. As an example, a carbamate may be considered as both -O- and -C(O)-NH- or a combination thereof.

In some embodiments, A_1 may be a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments, A_3 may be a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments, in particular in the two aforementioned ones, A_2 may represent the substituent of group a), more specifically a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, in particular hydrogen.

In some embodiments, A_1 may be a C_1-C_{60} moiety or polymeric moiety of group b). In some embodiments, A_2 and A_3 may represent substituents of group a), more specifically independently from each other a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, and in particular hydrogen.

In some embodiments, A_1 may be a C_1-C_{60} moiety of group b) and A_2 and A_3 may represent substituents of group a), more specifically independently from each other a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, and in particular hydrogen.

In some embodiments, the C_1-C_{30} moiety of group a) may comprise 1 to 30, more specifically 1 to 16, and in particular 1 to 12 carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 phosphorus atoms, and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms.

In some embodiments, the C_1-C_{30} moiety may be selected from a saturated or unsaturated, cyclic or acylic (hetero)alkyl comprising 1 to 30, more specifically 1 to 16, and in particular 1 to 12, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms; and/or the C_1-C_{30} moiety may be bound to L_1, L_2 and L_3, respectively, via a carbon atom, an oxygen atom, a nitrogen atom or a sulfur atom.

In some embodiments, A_3 may represent a C_1-C_{30} moiety of group a), more specifically a C_1-C_{16} moiety selected from a saturated or unsaturated, cyclic or acylic (hetero)alkyl comprising 1 to 16, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 oxygen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 6, more specifically 0 to 4, and in particular 0 to 3 halogen atoms.

In some embodiments, A_3 may represent a C_1-C_{16} moiety selected from a carboxylic acid or a salt thereof; a carboxylic ester; or a ketone.

In some embodiments, A_3 may represent a C_1-C_{16} moiety selected from a carboxylic acid or a salt thereof; a (C_1-C_4-alkyl)carboxylic ester; or a C_1-C_4-alkylcarbonyl.

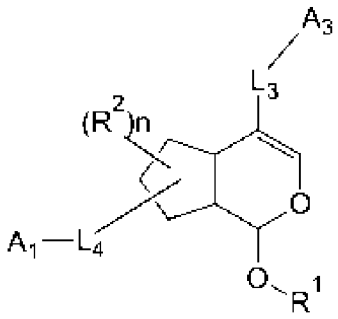
In some embodiments, L_1 and OR^1, together with the carbon atoms to which they are attached, may form a 5- or 6-membered lactone.

In some embodiments, R_1 may represent hydrogen, C_{1-6} acyl, or C_{1-6} alkyl. In some embodiments, it may be particularly advantageous that R_1 represents H. In some embodiments, it may be particularly advantageous that R_1 does not represent a glucoside.

In some embodiments, at least one of A_1, A_2 and A_3 may represent a C_1-C_{60} moiety or a polymeric moiety of group b1). In some embodiments, at least one of A_1 and A_2 may represent a C_1-C_{60} moiety of group b1).

In some embodiments, at least one of A_1, A_2 and A_3 may represent a C_1-C_{60} moiety or a polymeric moiety of group b2). In some embodiments, at least one of A_1 and A_2 may represent a C_1-C_{60} moiety of group b2).

In some embodiments, the compound capable of covalently binding to hair is a compound of formula (II), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(II);

wherein

R^1, L_3, A_1 and A_3 are as defined as in any preceding embodiment;

$(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;

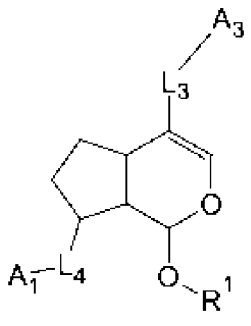
n is an integer selected from 1 and 2; and

L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof; and

R^4 is selected from H or C_1-C_4-alkyl.

In some embodiments of formula (II), at least one of A_1 and A_3 may represent a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments of formula (II), at least A_1 may represent a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments of formula (II), A_3 may represent a C_1-C_{30} moiety of group a), more specifically a C_1-C_{16} moiety selected from a saturated or unsaturated, cyclic or acylic (hetero)alkyl comprising 1 to 16, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 oxygen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 6, more specifically 0 to 4, and in particular 0 to 3 halogen atoms.

In some embodiments, the compound capable of covalently binding to hair is a compound of formula (III), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(III);

wherein

R^1, L_3, A_1 and A_3 are as defined in any preceding embodiment; and

L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof; and

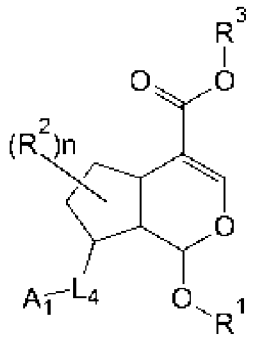
R^4 is selected from H or C_1-C_4-alkyl.

In some embodiments of formula (III), at least one of A_1 and A_3 may represent a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments of formula (III), at least A_1 may represent a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments of formula (III), A_3 may represent a C_1-C_{30} moiety of group a), more specifically a C_1-C_{16} moiety selected from a saturated or unsaturated, cyclic or acylic (hetero)alkyl comprising 1 to 16, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 oxygen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 6, more specifically 0 to 4, and in particular 0 to 3 halogen atoms.

In some embodiments of formula (III), L_3 represents -C(O)-, -C(O)-O-, -C(O)-NH-, or -C(O)-N(C_1-C_4-alkyl)-.

In some embodiments of formula (III), A_3 represents a group R^3 with R^3 representing a C_1-C_{14} moiety comprising 1 to 14, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms. It may be particularly advantageous that R^3 represents C_{1-14} alkyl, C_{2-14} alkenylene, C_{2-14} alkynylene, C_{6-14} aryl, C_{4-14} heteroaryl comprising 1 to 4 nitrogen atoms, 1 to 3 oxygen atoms and/or 1 to 2 sulfur atoms, wherein any of the aforementioned groups is optionally further substituted with the proviso that the aforementioned total sum of the elements recited for R^3 is not exceeded. It may also be advantageous that R^3 represents an optionally substituted phenyl. It may be especially advantageous that R^3 represents optionally substituted phenyl, in particular wherein the optionally substituted phenyl comprises 6 to 14, more specifically 6 to 12, and in particular 6 to 10, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms. In some of these embodiments, R^3 is substituted with one or more moieties selected from the group consisting of: -C_{1-4} alkyl, -O-C_{1-4} alkyl, -S-C_{1-4} alkyl, -NH-C_{1-4} alkyl, -N(C_{1-4} alkyl)$_2$, -C(O)C_{1-4} alkyl, -CO_2C_{1-4} alkyl, -O_2C-C_{1-4} alkyl, -C(O)NH-C_{1-4} alkyl, -C(O)N(C_{1-4} alkyl)$_2$, -NH-C(O)C_{1-4} alkyl, -N(C_{1-4} alkyl)-C(O)C_{1-4} alkyl, -SO_3H, -NO_2, -NH_2, -OH, -SH, -COOH, -C(O)H, halogen, in particular Cl, Br or F; and -CF_3.

In some embodiments of formula (III), the compound capable of covalently binding to hair is a compound of formula (IV), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(IV);

wherein

R^1 and A_1 are as defined in any preceding embodiment;

$(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;

n is an integer selected from 1 and 2;

L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof;

R^3 represents hydrogen or an optionally substituted hydrocarbon moiety comprising, in combination with their optional substituents, 1 to 14 carbon atoms; and

R^4 may be selected from H or C_1-C_4-alkyl.

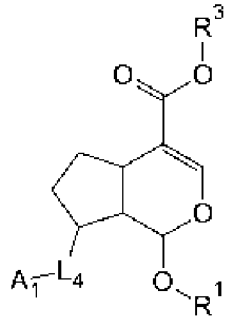
In some embodiments of formula (IV), A_1 may represent a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments of formula (IV), A_1 may represent a C_1-C_{60} moiety of group b).

In some embodiments of formula (IV), R^3 represents a C_1-C_{14} moiety comprising 1 to 14, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms. It may be particularly advantageous that R^3 represents C_{1-14} alkyl, C_{2-14} alkenylene, C_{2-14} alkynylene, C_{6-14} aryl, C_{4-14} heteroaryl comprising 1-4 nitrogen atoms, 1-3 oxygen atoms

and/or 1-2 sulfur atoms, wherein any of the aforementioned groups is optionally further substituted with the proviso that the aforementioned total sum of the elements recited for R^3 is not exceeded. It may also be advantageous that R^3 represents an optionally substituted phenyl. It may be especially advantageous that R^3 represents optionally substituted phenyl, in particular wherein the optionally substituted phenyl comprises 6 to 14, more specifically 6 to 12, and in particular 6 to 10, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms. In some of these embodiments, R^3 is substituted with one or more moieties selected from the group consisting of: -C_{1-4} alkyl, -O-C_{1-4} alkyl, -S-C_{1-4} alkyl, -NH-C_{1-4} alkyl, -N(C_{1-4} alkyl)$_2$, -C(O)C_{1-4} alkyl, -CO_2C_{1-4} alkyl, -O_2C-C_{1-4} alkyl, -C(O)NH-C_{1-4} alkyl, -C(O)N(C_{1-4} alkyl)$_2$, -NH-C(O)C_{1-4} alkyl, -N(C_{1-4} alkyl)-C(O)C_{1-4} alkyl, -SO_3H, -NO_2, -NH_2, -OH, -SH, -COOH, -C(O)H, halogen, in particular Cl, Br or F; and -CF_3.

In some embodiments of formula (IV), R^3 may represent a C_1-C_4 alkyl moiety or phenyl.

In some embodiments, the compound capable of covalently binding to hair is a compound of formula (V), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(V);

wherein

R^1 and A_1 are as defined in any preceding embodiment;

L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O- and -O-$(CH_2)_{1-4}$-, or combinations thereof;
R^3 represents a C_1-C_4 alkyl moiety or phenyl, or R^3 represents hydrogen or an optionally substituted hydrocarbon moiety comprising, in combination with their optional substituents, 1 to 14 carbon atoms; and
R^4 is selected from H or C_1-C_4-alkyl.

In some embodiments of formula (V), A_1 may represent a C_1-C_{60} moiety or a polymeric moiety of group b). In some embodiments of formula (V), A_1 may represent a C_1-C_{60} moiety of group b).

In some embodiments of formula (V), R^3 represents a C_1-C_{14} moiety comprising 1 to 14, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms. It may be particularly advantageous that R^3 represents C_{1-14} alkyl, C_{2-14} alkenylene, C_{2-14} alkynylene, C_{6-14} aryl, C_{4-14} heteroaryl comprising 1-4 nitrogen atoms, 1-3 oxygen atoms and/or 1-2 sulfur atoms, wherein any of the aforementioned groups is optionally further substituted with the proviso that the aforementioned total sum of the elements recited for R^3 is not exceeded. It may also be advantageous that R^3 represents an optionally substituted phenyl. It may be especially advantageous that R^3 represents optionally substituted phenyl, in particular wherein the optionally substituted phenyl comprises 6 to 14, more specifically 6 to 12, and in particular 6 to 10, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms. In some of these embodiments, R^3 is substituted with one or more moieties selected from the group consisting of: -C_{1-4} alkyl, -O-C_{1-4} alkyl, -S-C_{1-4} alkyl, -NH-C_{1-4} alkyl, -N(C_{1-4} alkyl)$_2$, -C(O)C_{1-4} alkyl, -CO_2C_{1-4} alkyl, -O_2C-C_{1-4} alkyl, -C(O)NH-C_{1-4} alkyl, -C(O)N(C_{1-4} alkyl)$_2$,

-NH-C(O)C_{1-4} alkyl, -N(C_{1-4} alkyl)-C(O)C_{1-4} alkyl, -SO_3H, -NO_2, -NH_2, -OH, -SH, -COOH, -C(O)H, halogen, in particular Cl, Br or F; and -CF_3.

In the following, the active components linked to the remainder of the compounds according to the invention will be discussed. For reasons of simplicity of language, reference to the active ingredient will be made as if the active ingredient is an individual compound instead of a moiety attached to the remainder of the compound. It should be understood that this is to be interpretated as a reference to a moiety that is attached to the remainder of the compound, typically be elimination of a hydrogen atom from the active ingredient.

It should further be understood that the below mentioned disclosure regarding the active components is freely combinable with the above disclosure relating to the compounds according to formulae (I) to (V). Indeed, these combinations represent preferred embodiments of the present disclosure, although it should be understood that the present disclosure is not limited thereto.

Compound acting as moisturizer

In some embodiments, at least one of A_1, A_2 and A_3 may be a C_1-C_{60} moiety or a polymeric moiety of group b) which is configured to act as a moisturizer, and/or which is configured to act as a moisturizer after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety may comprise a plurality of hydrogen bonding groups selected from the group consisting of hydroxyl groups, ether groups, carboxylic acids, amines and amides; and their salts.

In some embodiments, the plurality of hydrogen bonding groups may comprise three or more, more specifically 4 or more, and in particular 6 or more hydrogen bonding groups.

In some embodiments, the ratio of C-atoms to the sum of hydrogen bonding groups comprised in the C_1-C_{60} moiety or the polymeric moiety may be between about 4:1 to 1:1, more specifically between about 3:1 to about 1:1 and in particular between about 2:1 to about 1:1.

In some embodiments, the moiety is a C_1-C_{60} moiety, more specifically a C_1-C_{60} moiety having a molecular weight of at least 60 g/mol, more specifically at least 90 g/mol, and in particular at least 120 g/mol.

In some embodiments, the polymeric moiety may have a molecular weight ranging from 200 to 50000 g/mol.

In some embodiments, the moiety is a polymeric moiety.

In some embodiments, the ratio of C-atoms to the sum of heteroatoms comprised in the C_1-C_{60} moiety or the polymeric moiety may be between about 4:1 to 1:2, more specifically between about 3:1 to about 1:1.5, and in particular between about 2:1 to about 1:1, wherein the heteroatoms are selected from nitrogen and oxygen.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety may comprise:
a polyol, more specifically a polyol having n hydroxyl groups with n being 2 or more, 3 or more, 4 or more, 5 or more, 6 or more, 8 or more, 10 or more, 12 or more, or 16 or more;
a mono- or polyvalent carboxylic acid comprising one or more hydroxyl groups, more specifically glycolic acid, lactic acid, malic acid, tartaric acid or citric acid;
a sugar, more specifically a triose, a tetrose, a pentose a hexose, a monosaccharide, a disaccharide, a trisaccharide, an oligosaccharide, or a polysaccharide, in particular glucose, mannose, galactose, glucosamine, N-acetyl-D-glucosamine, myo-Inositol, rhamnose, lyxose, fucose, allose, ribose, arabinose, hyaluronic acid, in particular a hyaluronic acid having a molecular weight of less than 50,000 Dalton;
a sugar alcohol, more specifically a sugar alcohol comprising between 2 and 24 carbon atoms, in particular ethylene glycol, propylene glycol, glycerol, erythritol, threitol, arabitol,

xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, maltotriitol, or maltotetraitol; or
a sugar acid, more specifically an aldonic acid, an ulosonic acid, a uronic acid or an aldaric acid; or a salt thereof; or an ester thereof, in particular a C_1-C_4-alkylester thereof; or an amide thereof.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety may comprise a urea derivative; panthenol; or a diuride, in particular allantoin.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety may comprise an amino acid or amino acid derivative, more specifically serine, glycine, alanine, histidine, ornithine, arginine, cysteine, or pyroglutamic acid. In some embodiments, the amino acid may be present in its L-enantiomer. In some embodiments, the C_1-C_{60} moiety or polymeric moiety may comprise a plurality of amino acids or amino acid derivatives.

In some embodiments, the C_1-C_{60} moiety may have a molecular weight of 60 g/mol to 2000 g/mol, more specifically 90 g/mol to 1600 g/mol, and in particular 120 g/mol to 1200 g/mol.

In some embodiments, the C_1-C_{60} moiety of group b) may comprise an aliphatic C_{10}-C_{60} moiety, more specifically a C_{15}-C_{60} aliphatic moiety and in particular C_{20}-C_{60} aliphatic moiety; or an oligo- or polysiloxane, in particular a poly(di-C_1-C_4-alkyl)siloxane.

In some embodiments, the polymeric moiety is an oligo- or polysiloxane, in particular a poly(di-C_1-C_4-alkyl)siloxane. In some embodiments, the poly(di-C_1-C_4-alkyl)siloxane may have between 20 and 200 repeat units. In some embodiments, the poly(di-C_1-C_4-alkyl)siloxane is a polydimethysiloxane (dimethicone).

In some embodiments, the polymeric moiety is a polyether, in particular a polyether comprising ethylene oxide repeat units, propylene oxide repeat unity or mixtures thereof. Examples include polyethylene glycol (PEG) and polypropylene glycol (PPG).

In some embodiments, the polymeric moiety is a polyamine or a polymer comprising a polyamine such as PEG-15 tallow amine.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety may have a molecular weight of 140 g/mol to 2000 g/mol, more specifically 160 g/mol to 1600 g/mol, and in particular 180 g/mol to 1200 g/mol.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety may have more than 30 carbon atoms.

In some embodiments, the C_1-C_{60} moiety may comprise a saturated or unsaturated C_{10}-C_{60} aliphatic moiety, more specifically a C_{15}-C_{60} aliphatic moiety and in particular a C_{20}-C_{60} aliphatic moiety.

In some embodiments, the ratio of C-atoms to the sum of heteroatoms comprised in the C_1-C_{60} moiety or the polymeric moiety may be between about 60:1 to 5:1, more specifically between about 50:1 to about 10:1 and in particular between about 40:1 to about 20:1, wherein the heteroatoms are selected from nitrogen and oxygen.

In some embodiments, the C_1-C_{60} moiety may be a fatty acid, fatty alcohol or derivatives thereof, more specifically saturated or unsaturated fatty acids, fatty alcohols or derivatives thereof, and in particular caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, isostearic acid, linoleic acid, decyl alcohol, dodecyl alcohol, cetyl alcohol, stearyl alcohol, isostearyl alcohol or a fatty acid mono-,di- or triglyceride, in particular caprylic glyceride, capric glyceride or glyceryl stearate.

In some embodiments, the C_1-C_{60} moiety may be a sphingosine or a derivative thereof, in particular a ceramide or a sphingomyelin.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety of group b) may be configured to act as a moisturizer.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety of group b) may be configured to act as a moisturizer after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

In some embodiments in which the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a moisturizer, and/or is configured to act as a moisturizer, after being cleaved off of the 3,4-dihydro-2H-pyran moiety, it may be particularly advantageous that the compound of formula (I) is a compound of any one of formulae (II), (III), (IV) or (V) as defined above. It may also be particularly advantageous that R^1 represents H.

In all of the aforementioned embodiments, it may be advantageous that the moiety of group b) which is configured to act as a moisturizer, and/or which is configured to act as a moisturizer after being cleaved off of the 3,4-dihydro-2H-pyran moiety is a C_1-C_{60} moiety.

Compound acting as a cosmetic hair coating

In some embodiments, at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b) which is configured to act as a cosmetic hair coating, and/or which is configured to act as a cosmetic hair coating after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

In some embodiments, the cosmetic hair coating is providing a conditioning effect to the hair. Compounds providing a hair-conditioning effect are well-known in the art. Suitable examples include compounds/polymers having long hydrocarbon or siloxane backbones which help to lubricate the surface of the hair, thereby reducing the sensation of roughness

and assisting combing. Conventional conditioners often also contain quaternary cationic groups. These groups have a dual purpose: First, they help in attaching conventional conditioners to the hair. The outermost layer of a hair is rich in cysteine groups which are mildly acidic. When the hair is washed these groups can deprotonate, giving the hair a negative charge. Positively charged quaternary ammonium species can then become attached to the hair via electrostatic interactions. This functionality is of lesser importance for the present disclosure since the compounds attach to hair in a different manner. However, the surface coating of cationic groups also results in the hair being repelled from each other electrostatically which reduces clumping. Accordingly, while not essential, the C_1-C_{60} moiety or the polymeric moiety of group b) may also benefit from the presence of the quaternary cationic groups.

In some embodiments, the cosmetic hair coating is providing a gloss effect (or shine) to the hair. Compounds providing a gloss-effect or shine effect are well-known in the art. Typical examples include polymer having a high refractive index and examples (copolymers comprising polyether blocks and polysiloxane blocks) are, for instance, disclosed in European Patent Application EP 3 162 408 A1 which is incorporated herein in its entirety by reference thereto.

In some embodiments, the cosmetic hair coating is providing a reinforcing effect to the hair. When referring to a reinforcing effect, it is meant that the hair is physically coated with e.g. polymer to make it thicker and that the hair is provided with a coating that improves the styling performance of the hair (much like e.g. a styling gel would). Compounds providing such reinforcing effects are well-known in the art and include vinyl (co-)polymers such as polyvinyl pyrrolidone or a copolymer of dimethylamino-ethylmethacrylate and polyvinyl pyrrolidone. Such (co-)polymers are capable of forming hydrogen bonds along the entire polymer chain which provides the styling effect. Other suitable polymers include derivatives of polyethylene glycol. A reinforcing (styling) effect such as curling can also be provided by enriching the surface with moieties provided with one or more thiols. Examples of such moieties include cysteine and cysteine derivatives.

These thiols can be oxidized to dithiols (just as in a conventional perm) with an oxidizing agent (such as an peroxide) to provide the hair with a desired shape.

In some embodiments, the cosmetic hair coating is providing an anti-frizz effect to the hair. When referring to a reinforcing effect, it is meant that the frizziness of the hair is reduced. Compounds providing an anti-frizz effect are also well-known in the art and include compounds that can act as antistatic agents. Suitable compounds are well-known in the art and in particular encompass compounds/polymers which contain quaternary cationic groups and polycarboxylic acids or polycarboxylates, in particular a polyitaconate.

Accordingly, in some embodiments, the C_1-C_{60} moiety or the polymeric moiety of group b) which is configured to act as a cosmetic hair coating, and/or which is configured to act as a cosmetic hair coating after being cleaved off of the 3,4-dihydro-2H-pyran moiety may in particular be further characterized as follows:

In some embodiments, the cosmetic hair coating is providing a conditioning effect to the hair. Additionally or alternatively, the cosmetic hair coating is providing a gloss effect to the hair. Additionally or alternatively, the cosmetic hair coating is providing an anti-frizz effect to the hair. Additionally or alternatively, the cosmetic hair coating is providing a reinforcing effect to the hair.

In some embodiments, the moiety of group b) is a C_1-C_{60} moiety.

In some embodiments, the C_1-C_{60} moiety has a molecular weight of 60 g/mol to 2000 g/mol, more specifically 90 g/mol to 1600 g/mol, and in particular 120 g/mol to 1200 g/mol.

In some embodiments, the C_1-C_{60} moiety comprises an aliphatic C_{10}-C_{60} moiety, more specifically a C_{15}-C_{60} aliphatic moiety and in particular C_{20}-C_{60} aliphatic moiety.

In some embodiments, the C_1-C_{60} moiety comprises a saturated or unsaturated C_{10}-C_{60} aliphatic moiety, more specifically a C_{15}-C_{60} aliphatic moiety and in particular a C_{20}-C_{60} aliphatic moiety.

In some embodiments, the C_1-C_{60} moiety has more than 30 carbon atoms.

In some embodiments, the ratio of C-atoms to the sum of heteroatoms comprised in the C_1-C_{60} moiety is between about 60:1 to 1:1, more specifically between about 50:1 to about 5:1 and in particular between about 40:1 to about 10:1, wherein the heteroatoms are selected from nitrogen and oxygen.

In some embodiments, the C_1-C_{60} moiety is a sphingosine or a derivative thereof, in particular a ceramide or a sphingomyelin.

In some embodiments, the C_1-C_{60} moiety comprises a cation, in particular a quaternary cation. In some embodiments, the C_1-C_{60} moiety is positively charged. This refers to the overall charge of the moiety, i.e. the net sum of positive and negative charges.

In some embodiments, the C_1-C_{60} moiety comprises an anion, in particular a sulfate ion or a carboxylate ion. In some embodiments, the C_1-C_{60} moiety is negatively charged. This refers to the overall charge of the moiety, i.e. the net sum of positive and negative charges.

In some embodiments, the moiety of group b) is a polymeric moiety.

In some embodiments, the polymeric moiety comprises a cation, in particular a quaternary cation. In some embodiments, the polymeric moiety is positively charged. This refers to the overall charge of the moiety, i.e. the net sum of positive and negative charges.

In some embodiments, the polymeric moiety is a polyquaternium, in particular polyquaternium-16, polyquaternium-46, polyquaternium-11, polyquaternium-28,

polyquaternium-6, polyquaternium-7, polyquaternium-22, polyquaternium-39, polyquaternium-2, polyquaternium-17, or polyquaternium-18.

In some embodiments, the polymeric moiety comprises an anion, in particular a sulfate ion. In some embodiments, the polymeric moiety is negatively charged. This refers to the overall charge of the moiety, i.e. the net sum of positive and negative charges.

In some embodiments, the polymeric moiety is a polycarboxylic acid or a polycarboxylate, in particular a polyitaconate.

In some embodiments, the polymeric moiety comprises a polyether, more specifically a poly-(C_1-C_6)ether, and in particular polymers of ethylene oxide and/or propylene oxide.

In some embodiments, the polymeric moiety comprises a polymer comprising vinylpyrrolidone repeat units.

In some embodiments, the polymeric moiety comprises a polysiloxane, more specifically a poly(di-C_1-C_4-alkyl)siloxane and derivatives thereof. In some embodiments, the poly(di-C_1-C_4-alkyl)siloxane may have between 20 and 200 repeat units. In some embodiments, the polymeric moiety is a copolymer comprising polyether blocks and polysiloxane blocks.

In some embodiments, the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a cosmetic hair coating, in particular to provide a reinforcing (styling) effect, and is comprising one or more thiols, in particular one or more cysteine moieties or thiol-carrying derivatives thereof.

In some embodiments, in which the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a cosmetic hair coating, and/or is configured to act as a cosmetic hair coating after being cleaved off of the 3,4-dihydro-2H-pyran moiety, it may be particularly advantageous that the compound of formula (I) is a compound of any one of formulae (II),

(III), (IV) or (V) as defined above. It may also be particularly advantageous that R^1 represents H.

Compound acting as a primer for attaching dyes to the hair

In some embodiments, at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b) which is configured to act as a primer for attaching dyes to the hair.

Hair dyes and also reactive hair dyes are well-known in the art. The compounds of the present disclosure can be designed to provide chemical functionalities to the hair surface which subsequently allow the attachment of dyes and pigments or the attachment of precursors which develop to dyes and pigments after application of a developer (such as an oxidizing agent, e.g. a peroxide). In other words, the compounds of the present disclosure are priming the hair surface for the subsequent attachment/development of color on the hair. Two priming approaches are of particular relevance, namely enriching the hair with chemical groups which are naturally occurring in hair (hydroxyl, amines, sulfides, etc.) but not in sufficient number to adequately color the hair; and (additionally or alternatively) providing functional groups not naturally occurring in hair (e.g. aromatic diamines, aminophenols and resorcinol derivatives) to use their functionality to color the hair.

The above concept of hair dyeing may be particularly gentle to the hair, in particular since the core of the hair does not need to be made accessible to entrap the dye in the core of the hair.

Accordingly, in some embodiments, the C_1-C_{60} moiety or the polymeric moiety of group b) which is configured to act as a primer for attaching dyes to the hair may in particular be further characterized as follows:

In some embodiments, at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b) which is configured to act as a primer for attaching dyes to the hair.

In some embodiments, the moiety of group b) is a C_1-C_{60} moiety.

In some embodiments, the C_1-C_{60} moiety has a molecular weight of 60 g/mol to 2000 g/mol, more specifically 90 g/mol to 1600 g/mol, and in particular 120 g/mol to 1200 g/mol.

In some embodiments, the moiety which is configured to act as a primer for attaching dyes to the hair comprises hydroxyl groups and/or amino groups, in particular aromatic hydroxyl groups and/or aromatic amino groups.

In some embodiments, the moiety which is configured to act as a primer for attaching dyes to the hair is configured to react in the presence of an oxidizing agent (a developer) with a dye precursor under formation of a dye. In some embodiments, the dye precursor is selected from para-phenylenediamine and para-aminophenol. In some embodiments, the oxidizing agent is a peroxide, in particular hydrogen peroxide.

In some embodiments, the moiety which is configured to act as a primer for attaching dyes to the hair is an aromatic moiety comprising two or more functional groups selected from hydroxyls, primary, secondary or tertiary amines, and ethers.

In some embodiments, the moiety which is configured to act as a primer for attaching dyes to the hair is selected from resorcinol, m-aminophenol, 2-methyl-5-aminophenol, p-phenylenediamine, 2,4-diaminoanisole, 1,5-dihydroxynaphthalene, 4-methoxy-3-aminophenol, 2,4-diaminophenoxyethanol, m-diethylaminophenol and p-amino-o-cresol; and derivatives thereof.

In some embodiments, in which the C_1-C_{60} moiety or a polymeric moiety of group b) is configured to act as a primer for attaching dyes to the hair, it may be particularly advantageous that the compound of formula (I) is a compound of any one of formulae (II),

(III), (IV) or (V) as defined above. It may also be particularly advantageous that R^1 represents H.

Compound acting as a fragrance

In some embodiments, at least one of A_1, A_2 and A_3 may be a C_1-C_{60} moiety of group b) which is configured to act as a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

In some embodiments, the C_1-C_{60} moiety may comprise a functional group which couples the C_1-C_{60} moiety to the corresponding L_1, L_2 or L_3 moiety or, if the corresponding L_1, L_2 or L_3 moiety is absent, to the 3,4-dihydro-2H-pyran moiety. In some embodiments, said functional group is configured to be cleaved to an aldehyde, a ketone, a thiol, a hydroxyl or an amine.

In some embodiments, the functional group may be an imine, an acetal, a 1,1-diester, an enolether, an ester, an amide, a thioester, or a thioacetal.

In some embodiments, the C_1-C_{60} moiety may have a molecular mass after being cleaved off of less than 400 g/mol, more specifically less than 300 g/mol, and in particular less than 200 g/mol.

In some embodiments, the fragrance is selected from the group consisting of esters, aldehydes, ketones, thiols, lactones, alcohols, linear terpenes, cyclic terpenes, aromatics, and amines.

In some embodiments, the fragrance is not benzyl alcohol or hexanol.

In some embodiments in which the C_1-C_{60} moiety of group b) is configured to act as a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety, it may be particularly advantageous that the compound of formula (I) is a compound of any one of formulae (II),

(III), (IV) or (V) as defined above. It may also be particularly advantageous that R^1 represents H.

In some embodiments, the C_1-C_{60} moiety of group b) may not comprise or be derived from salicylic acid and its derivatives. In some embodiments, the compound and/or topical composition according to formula (I) does not comprise an ester of salicylic acid. This includes both esters formed with the hydroxyl group of salicylic acid and esters formed by the carboxylic acid of salicylic acid.

In some embodiments, the C_1-C_{60} moiety and/or the polymeric moiety of group b) is not a color-imparting moiety, in particular not a color-imparting moiety having at least one absorption peak within the wavelength range of 380 to 790 nm.

In some embodiments, the C_1-C_{60} moiety and/or the polymeric moiety of group b) is not a UV-absorbing moiety, in particular not a UVA- and/or UVB- absorbing moiety, in particular not a UVA- and/or UVB-absorbing moiety having at least one absorption peak within the wavelength range of 280 to 379 nm.

In some embodiments, the compound of formulae (I) to (V) is not a compound disclosed in the international application WO 2023/102652 A1, the contents of which are incorporated herein for this purpose by the reference thereto. Specifically, in some embodiments, the compound of any of formulae (I) to (V) is not a compound comprising a moiety A_1, A_2 and/or A_3 which is R^3 in formula (IX) of WO 2023/102652 A1.

In some embodiments, the compound of any of formulae (I) to (V) is not a compound disclosed in the international application WO 2023/102652 A1, the contents of which are incorporated herein for this purpose by the reference thereto.

In some embodiments, the compound of any of formulae (I) to (V) is not a compound disclosed in the international application WO 2014/155016 A1, and in particular not a compound disclosed in formulae (II) with $R"_1$, $R"_2$ and $R"_4$ being as defined in the table

beneath said formula and R"$_3$ representing $C_{12}H_{25}S$-. The contents of WO 2014/155016 A1 are incorporated herein for this purpose by the reference thereto.

In some embodiments, in case of A_3 representing a C_1-C_{60} moiety or polymeric moiety according to group b2) which is configured to act as a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety, A_3 does not represent a benzyloxy moiety or an alkoxy moiety, in particular hexyloxy.

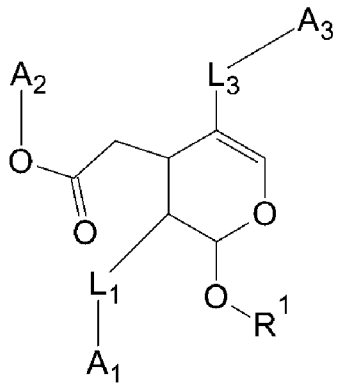
In some embodiments, the compound of formulae (I) and (II) is not a compound in which L_1-A_1 represents a moiety comprising a hydroxyl group attached to a carbon atom in alpha-position to the carbon atom marked "a" in formula (I).

In some embodiments, the compound of any of formulae (I) to (V) is not a compound disclosed in the US patent US 6,022,888, the contents of which are incorporated herein for this purpose by the reference thereto.

In some embodiments, the compounds of the present disclosure do not comprise an epoxy group.

Although the specific embodiments of the present disclosure have often been discussed with respect to hydrogenated genipin derivatives, it should be understood that the present disclosure is not limited to these derivatives. Rather, many alternative 3,4-dihydro-2H-pyran derivatives are available to the skilled person and equally suitable for and encompassed by the present disclosure. An alternative example, being based on a hydrogenated version of deglycosylated oleuropein, is described below.

Accordingly, in some embodiments, the compound of formula (I) capable of covalently binding to skin is a compound of formula (VI), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(VI);

wherein

R^1, L_1, L_3, A_1, A_2 and A_3 are as defined in any preceding embodiment, and wherein L_1 is in particular selected from the group consisting of -CH_2-, -C(O)-, C(O)-O-, -C(O)-NH-, -C(O)-N(C_1-C_4-alkyl)-, and combinations thereof.

Formulation

The hair care composition is not particularly limited and includes any such composition for administration to hair. An administration to hair in in the sense of the present disclosure refers to any local (i.e. not systemic) administration, whether through solutions, emulsions, ointments, gels, creams, lotions, or other similar formulations, of the compounds or compositions of the present disclosure, but excludes rectal, intrapulmonary and intranasal administration.

In the present application, a cosmetic or a cosmetic use means that the composition is suitable for external use (i.e. extracorporal use, e.g. not ingested) and is in particular suitable for application to hair.

The compositions of this disclosure may contain any one of the compounds of the present disclosure described herein in the range of 0.005wt.-% to 99wt.-% with the balance made up from the suitable excipients. The contemplated compositions may contain 0.01 wt.-%-

99 wt.-% of any one of the compounds provided herein, in one embodiment 0.1-95 wt.-%, in another embodiment 75-85 wt.-%, in a further embodiment 20-80 wt.-%, wherein the balance may be made up of any excipient described herein, or any combination of these excipients.

The topical composition according to the present disclosure further comprises an excipient suitable for topical administration. The excipient is not particularly limited. In some embodiments, the excipient suitable for topical administration comprises one or more excipients selected from water, ethanol, isopropanol, n-propanol, ethylene glycol, diethylene glycol, a propylene glycol, diethylene glycol monoethyl ether, DMSO, and glycerol.

In some embodiments, the topical composition can also be a pre-dispersed composition comprising the compound of this disclosure and a liquid carrier. These compositions can be a solution (e.g., free of any undissolved solid particles), a dispersion (e.g., containing a liquid phase and a solid precipitant phase), or an emulsion.

In some embodiments, the topical composition may contain water and/or organic solvents as suitable carriers and excipients. In one example, the liquid composition can be sterile and/or prepared from a sterile aqueous solution for infusion.

In some embodiments, the composition may also include a surface-active agents, such as an alkylbenzene sulfonate, an alkyl sulfate, an alkyl ether sulfate, a soap, an ethoxylate, an alkyl alcohol, a lignosulfonate, or a triglyceride.

The composition may also include a solid matrix. Suitable examples of a matrix component include a sugar, a sugar alcohol (e.g., sorbitol, mannitol, xylitol, isomalt, hydrogenated starch hydrolysates), a polymer, or a combination of two or more thereof.

In some embodiments, the composition may also include a preservative, a thickening agent, a film-forming agent and/or a humectant. Non-limiting examples of thickening agents

include starches, gums (e.g., natural and synthetic gums), cellulosics, and arabinogalactan. Non-limiting examples of humectants include polyhydric alcohols, for example, polyalkylene glycols (e.g., alkylene polyols and their derivatives), alpha hydroxy acids, sugars, Aloe vera gel, vegetable oil, lithium chloride, allantoin, urea, and dicyanamide. Non-limiting examples of film-forming agents include volatile silicone resins, polyvinylpyrrolidone, acrylates, acrylamides, copolymers, and isododecane resins.

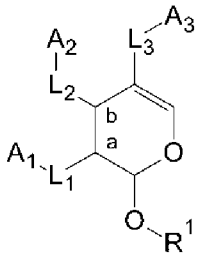
In some embodiments, the hair care formulation comprising the compound of formula (I) is storage stable (i.e., the compound of formula (I) retains its original chemical structure at greater than 95 mol.-%) for a period of time from greater than 1 month, more specifically greater than 3 months, and in particular greater than 6 months, when stored at 21°C and 25% RH. In some embodiments, aqueous solubility of the compound of formula (I) is from about 1 g/L to about 100 g/L, from about 5 g/L to about 50 g/L, or from about 10 g/L to about 100 g/L.

In some embodiments, it may be particularly advantageous that the topical composition is not too "runny" in order to facilitate that the topical formulation is retained locally on the skin at the site of administration. Accordingly, it may be particularly advantageous that the topical composition is having a dynamic viscosity, measured at 37°C, of more than 2 mPa·s, more specifically more than 10 mPa·s, and in particular more than 50 mPa·s, for instance, in the range of 2 mPa·s to 50,000 mPa·s, more specifically in the range of 10 mPa·s to 20,000 mPa·s, and in particular in the range of 50 mPa·s to 10,000 mPa·s. Suitable measuring methods are well-known in the art and include ASTM D-2196-20, using test method A at 30 rpm, or DIN EN ISO 2555:2018-09, at 30 rpm, on a rotational viscosimeter, for instance ViscoQC 100, optionally equipped with a PTD 100 Cone-Plate for smaller sample sizes, obtainable from Anton Paar GmbH, Germany.

In some embodiments, the hair care formulation is enclosed in a container. In some embodiments, the container is sealed and/or releasable after opening. In some embodiments, the container comprises a label and/or is provided with a packaging.

Further Uses and Methods

In a second aspect, the present disclosure relates to the use of a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

the C_1-C_{60} moiety or the polymeric moiety of group b) is

b1) configured to act as a moisturizer or a cosmetic hair coating; and/or

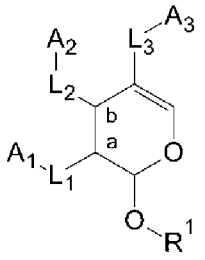
b2) configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety; and

L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively;

for providing a cosmetic effect to hair, more specifically to provide a moisturizing effect, a conditioning effect, a gloss effect, an anti-frizz effect, and/or an olfactory effect to hair.

Any of the specific compounds which are disclosed for the first aspect of the present disclosure also represent specific embodiments according to this aspect of the present disclosure.

In a third aspect, the present disclosure relates to a method of coloring hair, the method comprising applying a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof, to hair;



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

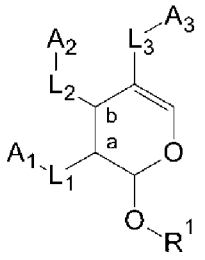
at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a primer for attaching dyes to the hair; and

L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively; and followed by contacting the primed hair with a dye, a pigment, a precursor of a dye, or a precursor of a pigment to effect a covalent attachment of a dye or a pigment to hair.

Related to this, there is also provided a kit-of-parts comprising:

a first container comprising a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a primer for attaching dyes to the hair; and

L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively; and

a second container comprising a dye, a pigment capable of reacting with the primer such that the dye or the pigment is attached to the hair via the primer, or comprising a precursor of a dye or pigment capable of reacting with the primer such that a dye or a pigment is generated when the precursor is attached to the hair via the primer. The attachment is preferably covalent.

Any of the specific compounds which are disclosed for the first aspect of the present disclosure and which are directed to a primer for attaching dyes to the hair also represent specific embodiments according to this aspect of the present disclosure.

In a fourth aspect, the present disclosure specifically relates to the compounds of the present disclosure per se, i.e. independent from the topical composition.

Any of the compounds which are disclosed for the first aspect of the present disclosure also represent specific embodiments according to this aspect of the present disclosure.

Definitions

As used herein, the term “hair” refers to hair and other fibrous keratinous materials such as eyebrows and eye lashes.

As used herein, the term "about" means "approximately" (e.g., plus or minus approximately 10% of the indicated value). For example, "about 20" means or includes amounts from 18 to and including 22.

At various places in the present specification, substituents of compounds of the invention are disclosed in groups or in ranges. It is specifically intended that the invention include each and every individual subcombination of the members of such groups and ranges. For example, the term “C_{1-6} alkyl” is specifically intended to individually disclose methyl, ethyl, C_3 alkyl, C_4 alkyl, C_5 alkyl, and C_6 alkyl.

As used herein, the term “carboxy” refers to a -C(O)OH group.

Throughout the definitions, the term “C_{n-m}” indicates a range which includes the endpoints, wherein n and m are integers and indicate the number of carbons. Examples include C_{1-4}, C_{1-6}, and the like.

As used herein, the term "C_{n-m} alkyl", employed alone or in combination with other terms, refers to a saturated hydrocarbon group that may be straight-chained or branched, having n to m carbons. Examples of alkyl moieties include, but are not limited to, chemical groups such as methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl, *tert*-butyl, isobutyl, *sec*-butyl; higher homologs such as 2-methyl-1-butyl, *n*-pentyl, 3-pentyl, *n*-hexyl, 1,2,2-trimethylpropyl, and the like. In some embodiments, the alkyl group contains from 1 to 6 carbon atoms, more specifically from 1 to 4 carbon atoms, even more specifically from 1 to 3 carbon atoms, and in particular 1 to 2 carbon atoms.

As used herein, the term "C_{n-m} acyl", employed alone or in combination with other terms, refers to a saturated hydrocarbon group that may be straight-chained or branched, having n to m carbons.

As used herein, the term "C_{n-m} haloalkyl", employed alone or in combination with other terms, refers to an alkyl group having from one halogen atom to 2s+1 halogen atoms which may be the same or different, where "s" is the number of carbon atoms in the alkyl group, wherein the alkyl group has n to m carbon atoms. In some embodiments, the haloalkyl group is fluorinated only. In some embodiments, the alkyl group has 1 to 6, 1 to 4, or 1 to 3 carbon atoms.

As used herein, "C_{n-m} alkenyl" refers to an alkyl group having one or more double carbon-carbon bonds and having n to m carbons. Example alkenyl groups include, but are not limited to, ethenyl, *n*-propenyl, isopropenyl, *n*-butenyl, *sec*-butenyl, and the like. In some embodiments, the alkenyl moiety contains 2 to 6, 2 to 4, or 2 to 3 carbon atoms.

As used herein, "C_{n-m} alkynyl" refers to an alkyl group having one or more triple carbon-carbon bonds and having n to m carbons. Example alkynyl groups include, but are not limited to, ethynyl, propyn-1-yl, propyn-2-yl, and the like. In some embodiments, the alkynyl moiety contains 2 to 6, 2 to 4, or 2 to 3 carbon atoms.

As used herein, the term "C_{n-m} alkylene", employed alone or in combination with other terms, refers to a divalent alkyl linking group having n to m carbons. Examples of alkylene groups include, but are not limited to, ethan-1,1-diyl, ethan-1,2-diyl, propan-1,1,-diyl, propan-1,3-diyl, propan-1,2-diyl, butan-1,4-diyl, butan-1,3-diyl, butan-1,2-diyl, 2-methyl-propan-1,3-diyl, and the like. In some embodiments, the alkylene moiety contains 2 to 6, 2 to 4, 2 to 3, 1 to 6, 1 to 4, or 1 to 2 carbon atoms.

As used herein, the term "amino" refers to a group of formula $-NH_2$.

As used herein, the term "fatty" in e.g. fatty acids or fatty alcohols, refers to linear-chain or branched-chain saturated, monounsaturated or polyunsaturated hydrocarbon moieties having between 8 and 34 carbon atoms. Examples of fatty acids include caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, arachidic acid, behenic acid, lignoceric acid, cerotic acid; linolenic acid, arachidonic acid, oleic acid and mead acid. Examples of fatty alcohols include decanol, undecanol, cetylalcohol, stearyl alcohol, oleyl alcohol, myricyl alcohol, and geddyl alcohol.

As used herein, the term "halogen" refers in particular to F, Cl, Br and I.

The term "compound" as used herein is meant to include all stereoisomers, geometric isomers, tautomers, and isotopes of the structures depicted. Compounds herein identified by name or structure as one particular tautomeric form are intended to include other tautomeric forms unless otherwise specified.

The compounds described herein can be asymmetric (*e.g.*, having one or more stereocenters). All stereoisomers, such as enantiomers and diastereomers, are intended unless otherwise indicated. Compounds of the present invention that contain asymmetrically substituted carbon atoms can be isolated in optically active or racemic forms. Methods on how to prepare optically active forms from optically inactive starting materials are known in the art, such as by resolution of racemic mixtures or by stereoselective synthesis. Many geometric isomers of olefins, C=N double bonds, N=N

double bonds, and the like can also be present in the compounds described herein, and all such stable isomers are contemplated in the present invention. *Cis* and *trans* geometric isomers of the compounds of the present invention are described and may be isolated as a mixture of isomers or as separated isomeric forms. In some embodiments, the compound has the *(R)*-configuration. In some embodiments, the compound has the *(S)*-configuration.

Compounds provided herein also include tautomeric forms. Tautomeric forms result from the swapping of a single bond with an adjacent double bond together with the concomitant migration of a proton. Tautomeric forms include prototropic tautomers which are isomeric protonation states having the same empirical formula and total charge. Example prototropic tautomers include ketone – enol pairs, amide - imidic acid pairs, lactam – lactim pairs, enamine – imine pairs, and annular forms where a proton can occupy two or more positions of a heterocyclic system, for example, 1H- and 3H-imidazole, 1H-, 2H- and 4H- 1,2,4-triazole, 1H- and 2H- isoindole, and 1H- and 2H-pyrazole. Tautomeric forms can be in equilibrium or sterically locked into one form by appropriate substitution.

As used herein, a "salt" or "pharmaceutically acceptable salt" of a compound of any one of the formulae disclosed herein is formed between an acid and a basic group of the compound, such as an amino functional group, or a base and an acidic group of the compound, such as a carboxyl functional group. According to another embodiment, the compound is a pharmaceutically acceptable acid addition salt. In some embodiments, acids commonly employed to form pharmaceutically acceptable salts of the compounds of any one of the formulae include inorganic acids such as hydrogen bisulfide, hydrochloric acid, hydrobromic acid, hydroiodic acid, sulfuric acid and phosphoric acid, as well as organic acids such as para-toluenesulfonic acid, salicylic acid, tartaric acid, bitartaric acid, ascorbic acid, maleic acid, besylic acid, fumaric acid, gluconic acid, glucuronic acid, formic acid, glutamic acid, methanesulfonic acid, ethanesulfonic acid, benzenesulfonic acid, lactic acid, oxalic acid, para-bromophenylsulfonic acid, carbonic acid, succinic acid, citric acid, benzoic acid and acetic acid, as well as related inorganic and organic acids. Such pharmaceutically acceptable salts thus include sulfate, pyrosulfate, bisulfate, sulfite, bisulfite, phosphate, monohydrogenphosphate, dihydrogenphosphate, metaphosphate,

pyrophosphate, chloride, bromide, iodide, acetate, propionate, decanoate, caprylate, acrylate, formate, isobutyrate, caprate, heptanoate, propiolate, oxalate, malonate, succinate, suberate, sebacate, fumarate, maleate, butyne-1,4-dioate, hexyne-l,6-dioate, benzoate, chlorobenzoate, methylbenzoate, dinitrobenzoate, hydroxybenzoate, methoxybenzoate, phthalate, terephthalate, sulfonate, xylene sulfonate, phenylacetate, phenylpropionate, phenylbutyrate, citrate, lactate, β-hydroxybutyrate, glycolate, maleate, tartrate, methanesu1fonate, propanesulfonate, naphthalene-1-sulfonate, naphthalene-2-sulfonate, mandelate and other salts. In one embodiment, pharmaceutically acceptable acid addition salts include those formed with mineral acids such as hydrochloric acid and hydrobromic acid, and especially those formed with organic acids such as maleic acid. In some embodiments, bases commonly employed to form pharmaceutically acceptable salts of the compounds of any one of the formulae disclosed herein include hydroxides of alkali metals, including sodium, potassium, and lithium; hydroxides of alkaline earth metals such as calcium and magnesium; hydroxides of other metals, such as aluminum and zinc; ammonia, organic amines such as unsubstituted or hydroxyl-substituted mono-, di-, or tri-alkylamines, dicyclohexylamine; tributyl amine; pyridine; N-methyl, N-ethylamine; diethylamine; triethylamine; mono-, bis-, or tris-(2-OH-(C_1-C_6)-alkylamine), such as N,N-dimethyl-N-(2-hydroxyethyl)amine or tri-(2-hydroxyethyl)amine; N-methyl-D-glucamine; morpholine; thiomorpholine; piperidine; pyrrolidine; and amino acids such as arginine, lysine, and the like. In some embodiments, the compounds of any one of the formulae disclosed herein, or salts thereof, are substantially isolated.

As used herein, the terms “individual” or “subject” are used interchangeably, and refer to any animal, including mammals, preferably mice, rats, other rodents, rabbits, dogs, cats, swine, cattle, sheep, horses, or primates, and most preferably humans.

The terms “protecting group” and “protective group” refer to a moiety that reversibly chemically modifies a functional group in order to obtain chemoselectivity or in order to reduce degradation in one or more subsequent chemical reactions. Suitable protecting groups are well known in the art (see, e.g., Greene and Wuts, Protective Groups in Organic

Synthesis, 3rd Ed., John Wiley & Sons, New York, N.Y., 1999, which is incorporated herein by reference in its entirety).

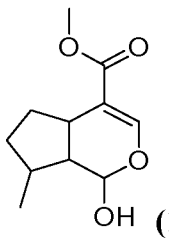
As used herein, "color" refers to wavelengths of electromagnetic radiation visible to the human eye and "colorless" refers to the absence of wavelengths of electromagnetic radiation visible to the human eye.

EXAMPLES

All starting materials/reagents/solvents were obtained from Sigma Aldrich, Thermo Fisher, VWR, TCI Chemicals, or Oakwood chemicals and used without purification. Genipin was supplied by Herb-Sun Biotechnology.

The following examples describe the synthesis of hydrogenated genipin derivatives and show the versatility and robustness of the 3,4-dihydro-2H-pyran moiety in coupling to keratinous tissues in in-vitro tests utilizing lysine. The examples also demonstrate that the lysine conjugates are colorless. Some of the examples are not according to the present disclosure since they do not carry a moiety of group b). These examples serve to demonstrate that the 3,4-dihydro-2H-pyran moiety can be broadly substituted while retaining the described effects (capability to bind to hair and colorless in the bound state).

Example 1 – preparation of genipin derivative compound methyl 1-hydroxy-7-methyl-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate (compound 1)



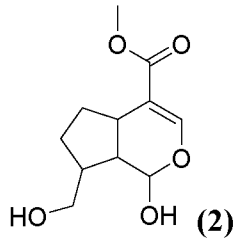
(1)

Genipin (methyl 1-hydroxy-7-(hydroxymethyl)-1,4a,5,7a-tetrahydrocyclopenta[c]pyran-4-carboxylate) (1 equivalent) was added to a Schlenk flask along with 10% Pd/C (10 wt.

%). The flask was cycled between vacuum and nitrogen gas three times. In a separate flask, nitrogen was bubbled into methanol for 15 minutes. Once complete, methanol was added slowly (0.05 M) to the Schlenk flask under flow of nitrogen. The Schlenk flask was put under vacuum and backfilled with H_2 via a balloon. The reaction was warmed to 50 °C and monitored by TLC until complete conversion of starting material. The crude reaction mixture was filtered through a pad of celite and flushed with dichloromethane. The filtered solution was concentrated and isolated by flash column chromatography as a mixture of diastereomers.

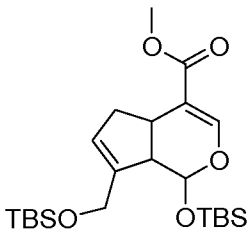
^{1}H NMR (300 MHz, $CDCl_3$) δ 7.42 (d, *J* = 1.3 Hz, 1H), 4.91 (t, *J* = 6.3 Hz, 1H), 3.71 (s, 3H), 2.89 (m, 1H), 2.35–2.14 (m, 1H), 2.11–1.94 (m, 1H), 1.94 – 1.78 (m, 1H), 1.64 (m, 1H), 1.35–1.15 (m, 2H), 1.11 (d, *J* = 6.7 Hz, 3H). **HRMS (DART+):** calculated for $C_{11}H_{17}O_4$ [M+H+]: 213.1121 m/z, found: 213.1124 m/z.

Example 2 – preparation of a hydrogenated genipin derivative compound methyl 1-hydroxy-7-(hydroxymethyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate (compound 2)



(2)

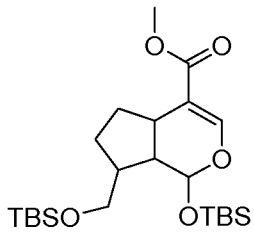
Step 1 – synthesis of methyl 1-((tert-butyldimethylsilyl)oxy)-7-(((tert-butyldimethylsilyl)oxy)methyl)-1,4a,5,7a-tetrahydrocyclopenta[c]pyran-4-carboxylate



Genipin (1 equivalent) was added to an oven-dried round bottom flask along with tert-butyldimethylsilyl chloride (2.4 equivalents) and imidazole (5 equivalents). The reagents

were then dissolved in dimethylformamide (0.3 M) and stirred at room temperature for 4 days. After completion, the crude reaction mixture was added to a separatory funnel with ethyl acetate and brine. Organic phase was washed with brine three times. The combined aqueous layer was extracted with ethyl acetate two times. The combined organic phase was dried with magnesium sulfate and concentrated using a rotary evaporator. The title compound was isolated via flash column chromatography using a gradient of ethyl acetate and hexane.

Step 2 – synthesis of methyl 1-((tert-butyldimethylsilyl)oxy)-7-(((tert-butyldimethylsilyl)oxy)methyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate



The product of step 1 (1 equivalent) was added to a Schlenk flask along with 10% Pd/C (10 wt. %). The flask was cycled between vacuum and nitrogen gas three times. In a separate flask, nitrogen was bubbled into methanol for 15 minutes. Once complete, methanol was added slowly (0.05 M) to the Schlenk flask under flow of nitrogen. The Schlenk flask was put under vacuum and backfilled with H_2 via balloon. The reaction was warmed to 50 °C and monitored by TLC until complete conversion of starting material. The crude reaction mixture was filtered through a pad of celite and flushed with dichloromethane. The filtered solution was concentrated and isolated by flash column chromatography as a mixture of diastereomers.

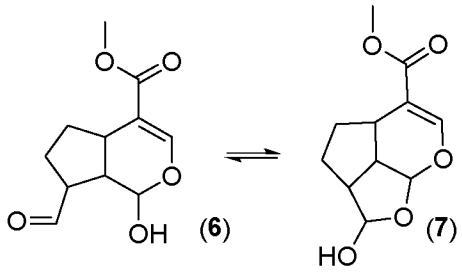
Step 3 – synthesis of methyl 1-hydroxy-7-(hydroxymethyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate

The product of step 2 (1 equivalent) was added to an oven-dried flask and dissolved in THF (0.04 M). To this was added TBAF (1 equivalent from a 1 M solution in THF), and the

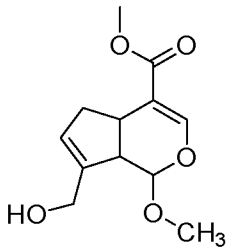
reaction was stirred for 1 hour. The crude reaction mixture was concentrated, and the desired compound (3) was isolated via flash column chromatography.

^{1}H NMR (400 MHz, MeOD) δ 7.48 (s, 1H), 3.70 (s, 3H), 3.64–3.56 (m, 1H), 3.51 (m, 1H), 2.80–2.70 (m, 1H), 2.27–2.07 (m, 2H), 2.00–1.64 (m, 3H), 1.50–1.19 (m, 3H). **HRMS (DART+):** calculated for $C_{11}H_{17}O_5$ [M+H+]: 229.1070 m/z, found: 229.1066 m/z.

Example 3 – preparation of genipin derivative compound methyl 7-formyl-1-hydroxy-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate (compound 6) and genipin derivative compound methyl 3-hydroxy-1,2a,2a1,3,4a,7a-hexahydro-2H-4,5-dioxacyclopenta[cd]indene-7-carboxylate (compound 7)

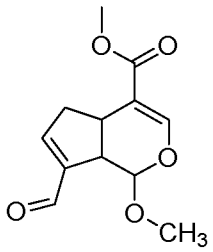


Step 1 - methyl 7-(hydroxymethyl)-1-methoxy-1,4a,5,7a-tetrahydrocyclopenta[c]pyran-4-carboxylate



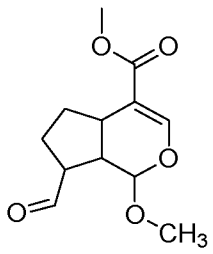
Genipin (1 equivalent) was added to a round bottom flask and dissolved with methanol (0.05 M). Para-toluenesulfonic acid (0.3 equivalent) was added to the stirring solution of genipin and allowed to react at room temperature until complete conversion of starting material. Once complete, the crude material was concentrated using rotary evaporation and filtered through a plug of silica. The crude material was flushed with dichloromethane and concentrated. The title compound was isolated via flash column chromatography.

Step 2 - methyl 7-formyl-1-methoxy-1,4a,5,7a-tetrahydrocyclopenta[c]pyran-4-carboxylate



To a stirring solution of the product of step 1 (1 equivalent) in dichloromethane, was added Dess-Martin periodinane (DMP) (1.2 equivalent). The reaction was allowed to stir for 24 hours. Once complete, a saturated solution of $NaHCO_3$ and $Na_2S_2O_3$ were added sequentially to the reaction mixture and stirred for 30 minutes. The biphasic mixture was added to a separatory funnel and extracted with dichloromethane/water (3X) followed by brine. The combined organic layer was dried with $MgSO_4$ and concentrated under reduced pressure. The crude material was dry loaded onto silica and purified by flash chromatography (hexane: ethyl acetate) to give the title compound.

Step 3 - methyl 7-formyl-1-methoxy-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate



Product of step 2 (1 equivalent) was added to a Schlenk flask along with 10% Pd/C (10 wt. %). The flask was cycled between vacuum and nitrogen gas three times. In a separate flask, nitrogen was bubbled into methanol for 15 minutes. Once complete, methanol was added slowly (0.05 M) to the Schlenk flask under flow of nitrogen. The Schlenk flask was put under vacuum and backfilled with H_2 via balloon. The reaction was warmed to 50 °C and monitored by TLC until complete conversion of starting material. The crude reaction

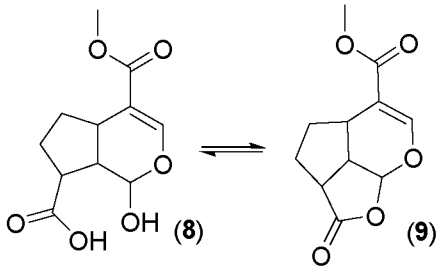
mixture was filtered through a pad of celite and flushed with dichloromethane. The filtered solution was concentrated and isolated by flash column chromatography as a mixture of diastereomers (the title compound).

Step 4 – synthesis of compound 6 and 7

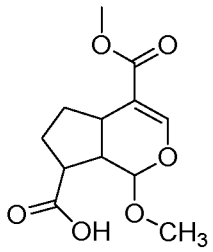
Product of step 3 was dissolved in acetic acid/1 M HCl/THF in a 3:2:5 ratio at an overall concentration of 0.07 M. The solution was stirred overnight at 60 °C. Once complete, the solution was poured into a separatory funnel with water and ethyl acetate. The combined ethyl acetate extract was dried with sodium sulfate and concentrated under reduced pressure. The desired compound (as a 15:85 mixture of aldehyde compound 6/acetal compound 7) was isolated via flash column chromatography (hexane:ethyl acetate).

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.79 (s, 0.05 H), 9.97 (s, 0.11 H) 7.56–7.44 (m, 1H), 6.07 (d, J = 5.9 Hz, 0.05 H), 5.90–5.82 (m, 0.55 H), 5.74 (d, J = 5.0 Hz, 0.11 H), 5.36 (d, J = 4.9 Hz, 0.05 H), 5.11 (d, J = 1.6 Hz, 0.55 H), 5.03 (d, J = 1.5 Hz, 0.11 H), 4.91 (d, J = 7.5 Hz, 0.15 H), 3.74 (m, 3H), 3.61–3.55 (m, 0.05 H), 3.38 (t, J = 7.4 Hz, 0.05 H), 3.02 (m, 0.75 H), 2.94–2.78 (m, 1H), 2.76–2.58 (m, 1.4 H), 2.56–2.43 (m, 0.20 H), 2.39–2.22 (m, 1H), 2.06 (m, 0.25 H), 1.93–1.80 (m, 1H), 1.72 (m, 1H), 1.44 (m, 0.11 H), 1.15 (m, 0.8 H).
HRMS (DART+): calculated for $C_{11}H_{15}O_5$ [M+H+]: 227.0914 m/z, found: 227.0913 m/z.

Example 4 – synthesis of 1-hydroxy-4-(methoxycarbonyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-7-carboxylic acid (compound 8) and methyl 3-oxo-1,2a,2a1,3,4a,7a-hexahydro-2H-4,5-dioxacyclopenta[cd]indene-7-carboxylate (compound 9)



Step 1 – synthesis of 1-methoxy-4-(methoxycarbonyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-7-carboxylic acid



The product of step 3 of example 3 was dissolved in dimethylformamide (0.2 M) and stirred with 4 equivalents of potassium peroxymonosulfate for 48 hours. The crude material was added to a separatory funnel with ethyl acetate and brine. The combined ethyl acetate was dried with sodium sulfate and concentrated before isolation via flash column chromatography to give the title compound.

Step 2 - synthesis of compound 8 and compound 9

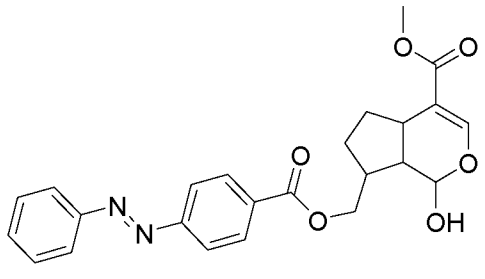
The product of step 1 was dissolved in acetic acid/1 M HCl/THF in a 3:2:5 ratio at an overall concentration of 0.07 M. The solution was stirred overnight at 60 °C. Once complete, the solution was poured into a separatory funnel with water and ethyl acetate. The combined ethyl acetate extract was dried with sodium sulfate and concentrated. The title compound was isolated via flash column chromatography (hexane : ethyl acetate) to give the desired compound below.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (d, *J* = 1.2 Hz, 1H), 6.05 (d, *J* = 5.9 Hz, 1H), 3.75 (s, 3H), 3.41 – 3.32 (m, 1H), 2.97 (ddd, *J* = 10.6, 7.7, 5.9 Hz, 1H), 2.93 – 2.81 (m, 1H), 2.54 – 2.43 (m, 1H), 2.26 (dd, *J* = 12.9, 6.0 Hz, 1H), 1.76 (tdd, *J* = 13.2, 7.1, 6.2 Hz, 1H), 1.10 (tdd, *J* = 13.2, 11.4, 6.0 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 167.1, 148.5, 110.0, 96.9, 51.7, 48.8, 37.5, 33.4, 31.7, 29.0.

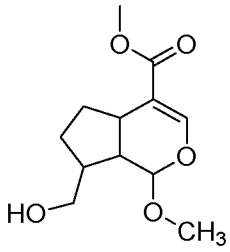
HRMS (DART+): calculated for $C_{11}H_{13}O_5$ [M+H+]: 225.0758 m/z, found: 225.0751 m/z.

Example 5 – synthesis of methyl (E)-1-hydroxy-7-(((4-(phenyldiazenyl)benzoyl)oxy)methyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate (compound 10)



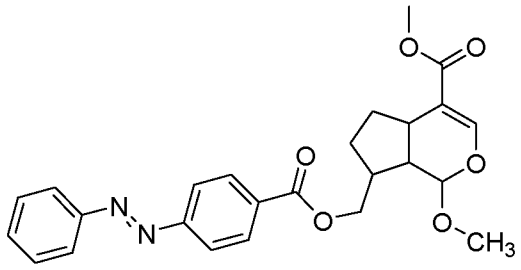
(10)

Step 1 – synthesis of methyl 7-(hydroxymethyl)-1-methoxy-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate



The compound obtained in step 3 of example 3 (1 equivalent) was dissolved in methanol (0.27 M) and stirred at 0 °C. To this, was added sodium borohydride (1.5 equivalents). The reaction was stirred for 30 minutes as it warmed to room temperature. Once complete, the crude reaction mixture was diluted with saturated NH_4Cl and extracted with ethyl acetate (3X) in a separatory funnel. The combined organic phase was dried with sodium sulfate and concentrated under reduced pressure. Title compound was isolated via flash column chromatography.

Step 2 – synthesis of methyl (E)-1-methoxy-7-(((4-(phenyldiazenyl)benzoyl)oxy)methyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate



The compound obtained in step 1 (1 equivalent) was dissolved in dichloromethane/pyridine (1:1 v/v) (0.2 M) and cooled to 0 °C. 4-(phenylazo)benzoyl chloride (1.2 equivalents) was added dropwise at 0 °C and allowed to react overnight while warming to room temperature. The crude reaction mixture was quenched with saturated sodium bicarbonate and extracted in a separatory funnel with dichloromethane and water. The combined DCM layer was dried with sodium sulfate, concentrated under reduced pressure and isolated via flash column chromatography to give the title compound.

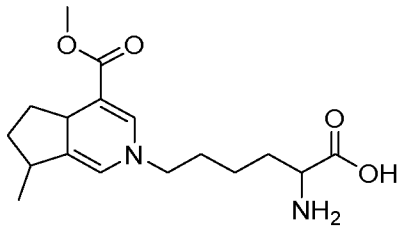
Step 3 – synthesis of the title compound of this example

The product of step 2 was dissolved in acetic acid/1M HCl/THF in a 3:2:5 ratio at an overall concentration of 0.07 M. The solution was stirred overnight at 60 °C. Once complete, the solution was poured into a separatory funnel with water and ethyl acetate. The combined ethyl acetate extract was dried with sodium sulfate and concentrated under reduced pressure. The title compound was isolated via flash column chromatography (hexane:ethyl acetate) to give the desired compound (10).

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.22–8.15 (m, 2H), 7.99–7.91 (m, 4H), 7.59–7.50 (m, 3H), 7.45 (m, 1H), 5.66 (t, *J* = 3.7 Hz, 0.3 H), 5.19–5.09 (m, 0.65 H), 4.69 (dd, *J* = 11.2, 7.3 Hz, 0.65 H), 4.56 (d, *J* = 8.0 Hz, 0.6 H), 4.46 (dd, *J* = 11.3, 7.4 Hz, 0.6 H), 3.74 (s, 3H), 3.69 (m, 1H), 3.63–3.55 (m, 2H), 3.08 (m, 0.3 H), 2.98 (m, 0.7 H), 2.79 (m, 1H), 2.45–2.18 (m, 2H), 2.12–2.03 (m, 0.6 H), 1.95–1.81 (m, 2H), 1.79–1.59 (m, 3H), 1.55–1.41 (m, 0.6 H).
HRMS (DART+): calculated for $C_{24}H_{25}N_2O_6$ [M+H+]: 437.1707 m/z, found: 437.1714 m/z.

Example 6 – Conjugation to lysine and color properties of hydrogenated genipin

A hydrogenated genipin derivative (compound 1) was conjugated with lysine to obtain compound 1-lysine conjugate:



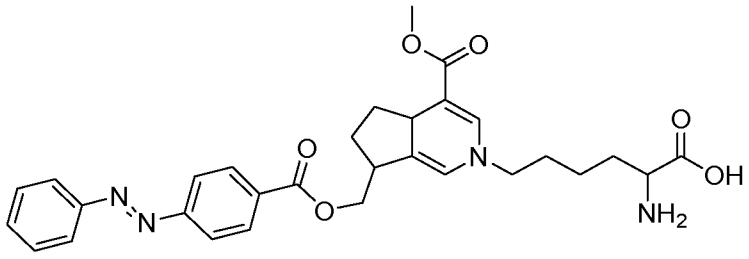
As shown in Figure 2, reacting the anchor compound (1) with the amino acid to mimic hair binding results in a small shift in the compound's strong UV-absorption (absorbance at wavelengths below 410 nm), but no visible color (no absorbance at wavelengths above 410 nm).

Figure 3A shows that reacting the anchor compound (2) with lysine to mimic hair binding results in strong UV-light absorption and no visible color.

Figure 3B shows that reacting the anchor compound (6)/(7) with lysine to mimic hair binding results in UV-light absorption and no visible color.

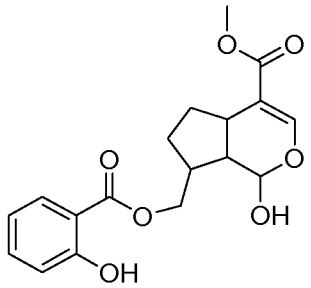
Figure 3C shows that reacting the anchor compound (8)/(9) with lysine to mimic hair binding results in UV-light absorption and no visible color.

The azo-dye compound of example 5 (compound 10) was conjugated with lysine to obtain a conjugate:

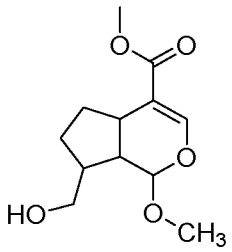


As shown in Figure 3D reacting the dye conjugate of the anchor compound with the amino acid to mimic hair binding results in a color due to the presence of the azo dye moiety. However, the conjugation process does not alter absorbance properties of the compound from prior to conjugation with lysine.

Example 7 - methyl 1-hydroxy-7-(((2-hydroxybenzoyl)oxy)methyl)-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate



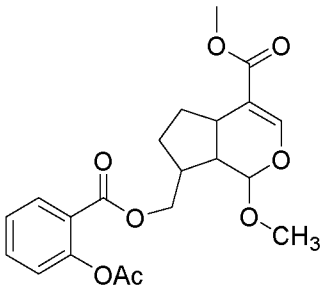
Step 1 – synthesis of methyl 7-(hydroxymethyl)-1-methoxy-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate



The compound obtained in step 3 of example 3 (1 equivalent) was dissolved in methanol (0.27 M) and stirred at 0 °C. To this, was added sodium borohydride (1.5 equivalents). The reaction was stirred for 30 minutes as it warmed to room temperature. Once complete, the

crude reaction mixture was diluted with saturated NH_4Cl and extracted with ethyl acetate (3X) in a separatory funnel. The combined organic phase was dried with sodium sulfate and concentrated under reduced pressure. Title compound was isolated via flash column chromatography.

Step 2 – synthesis of methyl 7-(((2-acetoxybenzoyl)oxy)methyl)-1-methoxy-1,4a,5,6,7,7a-hexahydrocyclopenta[c]pyran-4-carboxylate



The product of step 1 (1 equivalent) was dissolved in dichloromethane/pyridine (1:1 v/v) (0.2 M) and cooled to 0 °C. O-acetylsalicyloyl chloride (1.2 equivalents) was added dropwise at 0 °C and allowed to react overnight while warming to room temperature. The crude reaction mixture was quenched with saturated sodium bicarbonate and extracted in a separatory funnel with dichloromethane and water. The combined DCM layer was dried with sodium sulfate, concentrated under reduced pressure and isolated via flash column chromatography to give the title compound.

Step 3 - synthesis of the title compound of this example

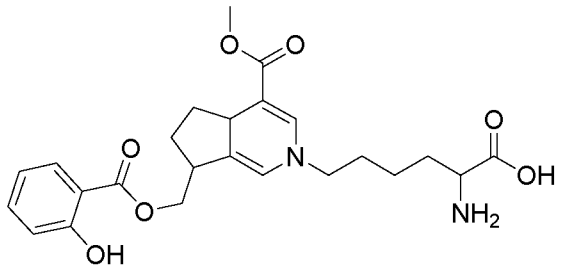
The product of step 2 was dissolved in acetic acid/1 M HCl/THF in a 3:2:5 ratio at an overall concentration of 0.07 M. The solution was stirred overnight at 60 °C. Once complete, the solution was poured into a separatory funnel with water and ethyl acetate. The combined ethyl acetate extract was dried with sodium sulfate and concentrated under reduced pressure. The title compound was isolated via flash column chromatography (hexane:ethyl acetate) to give the desired compound.

^{1}H NMR (400 MHz, $CDCl_3$) δ 10.79 (s, 0.25 H), 10.77 (s, 0.6 H), 7.84 (m, 1H), 7.49–7.45 (m, 2H), 7.01 (m, 1H), 6.91 (m, 1H), 5.65 (t, *J* = 3.6 Hz, 0.25 H), 5.15 (dd, *J* = 8.5, 6.5 Hz, 0.7 H), 4.67 (dd, *J* = 11.1, 7.2 Hz, 0.7 H), 4.58 (d, *J* = 8.2 Hz, 0.5 H), 4.48 (dd, *J* = 11.2, 7.6 Hz, 0.7 H), 3.76 (m, 3H), 3.34 (m, 0.7 H), 3.00 (m, 1H), 2.95–2.68 (m, 1H), 2.46–2.30 (m, 1H), 2.26 (m, 0.7 H), 2.18–1.89 (m, 1H), 1.83–1.43 (m, 2H).

HRMS (DART+): calculated for $C_{18}H_{24}NO_7$ [M+NH+]: 366.1547 m/z, found: 366.1550 m/z.

Example 8 – Conjugation with lysine

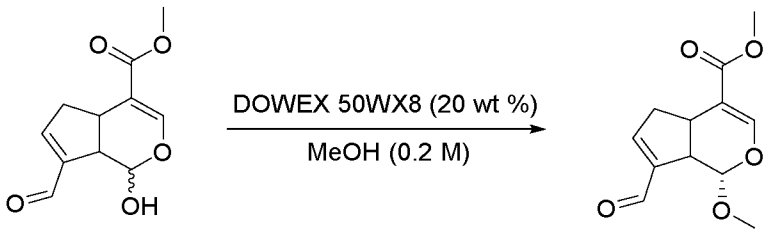
The compound of Example 7 was conjugated with lysine to obtain the lysine conjugate:



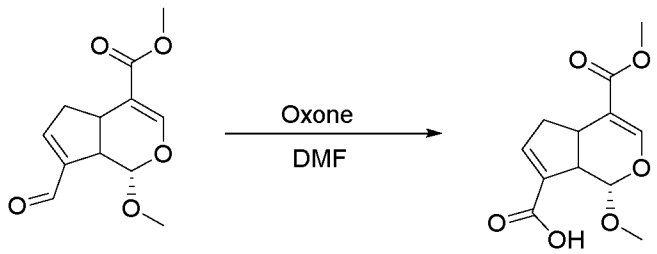
As shown in Figure 4, reacting the compound of Example 7 (i.e. a hydrogenated genipin salicylate, called "genipin salicylate" in Fig. 7) with the amino acid lysine (called "amine" in Fig. 4) to mimic hair binding results in small shift in UV absorbance peak (no visible color is produced).

All of the above examples are not according to the present disclosure due to the lack of C_1-C_{60} moiety or of a polymeric moiety of group b)

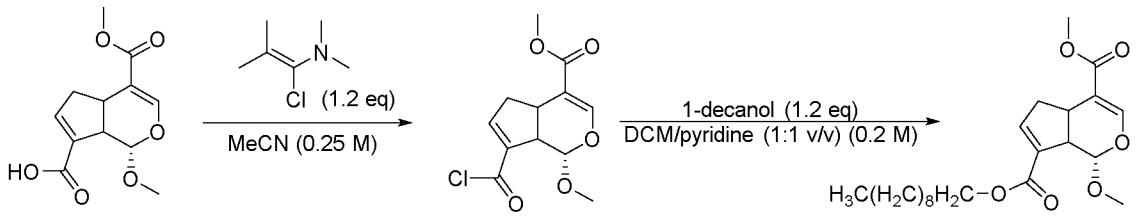
Example 9 – Preparation and conjugation with lysine



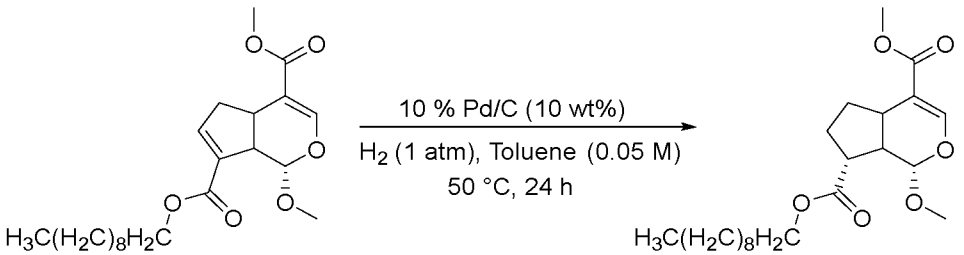
The aldehyde, obtainable as described in WO 2022/036113 A1, was weighed and transferred to a round bottom flask. To this, was added MeOH (0.2 M) and stirred until fully solubilized. DOWEX 50WX8 was first washed with methanol and dried under vacuum. Once dry, the DOWEX 50WX8 (H+ form) was added to the stirred solution of aldehyde. The reaction mixture was heated at 40 °C for 65 hours. Once complete, the methanol was removed via rotary evaporation and the product was precipitated using ether/hexane to obtain a white powder.



The obtained aldehyde was added to a suspension of Oxone® (potassium peroxymonosulfate; 4 equivalents) in DMF (0.2 M), and the reaction mixture was stirred at room temperature for four days. The crude mixture was added to a separatory funnel with ethyl acetate and brine. The aqueous layer was washed thoroughly with ethyl acetate. The combined ethyl acetate layers were subsequently extracted (3x) with saturated $NHCO_3$. The combined aqueous basic layer was re-acidified with concentrated HCl until the pH was below 7. The acidified solution was then extracted with ethyl acetate (3x). The combined ethyl acetate layer was dried with Na_2SO_4 and concentrated.

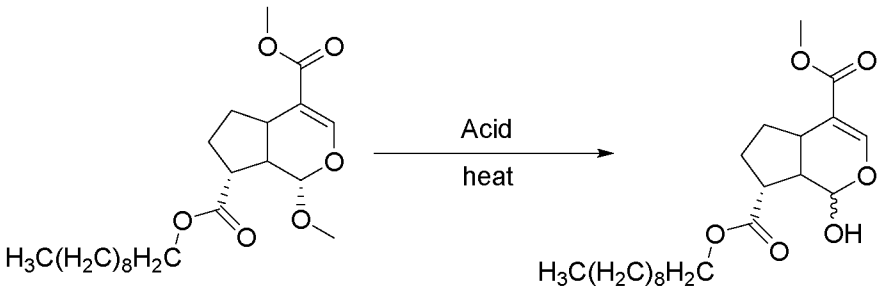


To a solution of the carboxylic acid in MeCN (0.25 M) was added 1-chloro-N,N-2-trimethyl-1-propenylamine at 0 °C for 1 h. Once the starting material was consumed (verified by TLC), the mixture was concentrated to an oil under vacuum. Once concentrated, dichloromethane (0.2 M) was added to the reaction mixture and stirred at 0 °C. To this, was added 1-decanol, and then pyridine (equal volume to dichloromethane). The ice bath was removed, and the mixture was allowed to warm to room temperature for 1 hour. Once complete the reaction was diluted with DCM and transferred to a separatory funnel. Wash with 1 M HCl (2X) to remove pyridine. Wash with saturated $NaHCO_3$ (1X) to remove unreacted acyl chloride. Dry with sodium sulfate and concentrate to dryness. The resultant material was purified via flash column chromatography using a gradient of ethyl acetate and hexanes.



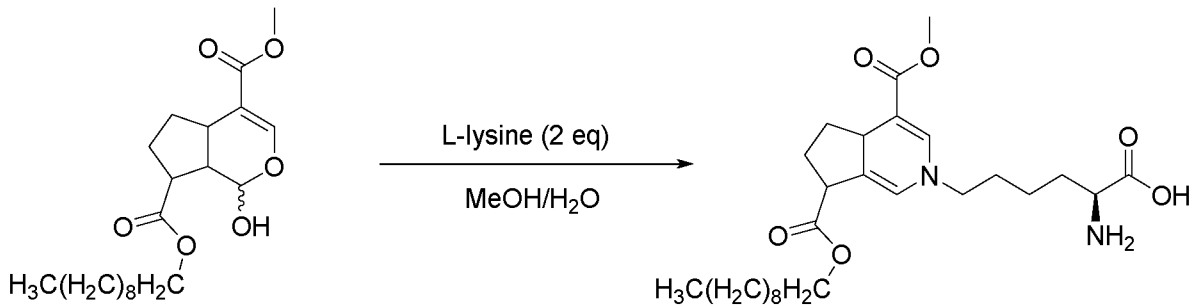
10 % Palladium on carbon (10 wt%) was weighed into an oven dried Schlenk flask. The flask was cycled between argon and vacuum 3 times. In a separate Erlenmeyer flask was added toluene equipped with a stir bar. A needle connected to a hose on the argon line was submerged into the toluene and bubbled through the solvent for 15 minutes. Meanwhile, the ester material was weighed into a vial. Once the toluene sparge was complete, the ester starting material was dissolved in degassed toluene. This solution is carefully added to the Schlenk flask under a flow of argon. Once complete, a rubber septum was placed on the

Schlenk flask and evacuated under vacuum, then left under static vacuum. A balloon was filled with H_2 and equipped with an 18 G needle. The balloon was added to the reaction flask, warmed to 50 °C, and allowed to react for 24 hours. The crude reaction was carried forward to the next step without further purification.



The reduced ester starting material was deprotected using a mixture of HCl/acetic acid in tetrahydrofuran while heating for prolonged periods. The crude reaction mixture was added to a separatory funnel and carefully quenched with a saturated solution of sodium bicarbonate and extracted with ethyl acetate. The combined organic phases were dried with sodium sulfate and concentrated in vacuo. The crude material was isolated via flash column chromatography using a gradient of ethyl acetate and hexanes.

HRMS (DART+): calculated for $C_{21}H_{35}O_6$ [M+H$^+$]: 383.2428 m/z, found: 383.2420 m/z



^{1}H NMR (400 MHz, CDCl3) *mixture of diastereomers* δ 7.45 (m, 1H – mixture integrate as 1), 5.51 (d, J = 8.0 Hz, 0.33H), 5.34–4.72 (m, 1H), 4.18–4.00 (m, 2H), 3.71 (s, 3H), 3.12

(m 0.36 H), 3.07–2.87 (m, 1H), 2.80 (m, 1H), 2.69–2.39 (m, 1H), 2.32 (m, 1H), 2.10–1.92 (m, 2H), 1.92–1.76 (m, 1H), 1.63 (m 2H), 1.48–1.18 (m, 15H), 0.94–0.82 (m, 3H).

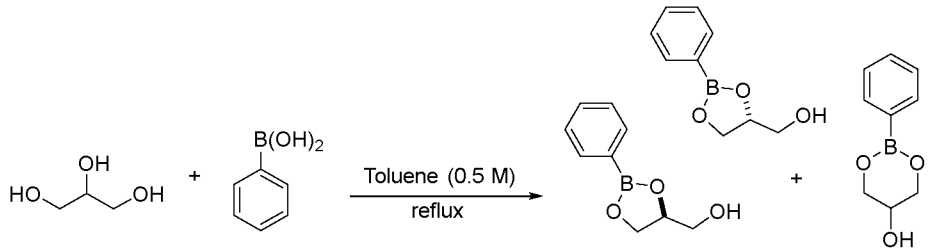
The deprotected species from the previous step was reacted with L-lysine (2 molar equivalents) in MeOH (0.05 M) with a few drops of water and stirred for 18 hours at 35 °C.

HRMS (DART+): calculated for $C_{27}H_{45}N_2O_6$ [M+H$^+$]: 493.3272 m/z, found: 493.3267 m/z

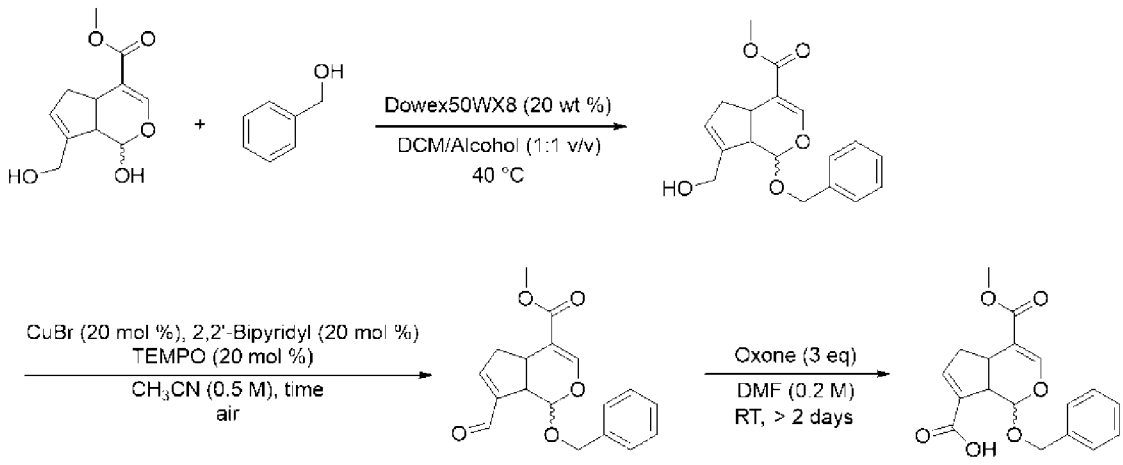
As shown in Fig. 5., the obtained lysine conjugate (B) was nearly colorless (very pale yellow).

Example 10 – Preparation of a hydrogenated genipin derivative linked to glycerol and its conjugation to lysine

Starting material synthesis:



To a stirring solution of glycerol in toluene (0.5 M) was added an equimolar amount of phenylboronic acid. The mixture was warmed to reflux for 5 hours before concentrating the reaction mixture via rotary evaporation. Fresh toluene was added 3 times and evaporated to remove excess water. The resultant glycerol boronic esters are a mixture of isomers and carried to the next step.



Step 1: O-benzyl protection of genipin: benzyl 7-(hydroxymethyl)-1-methoxy-1,4a,5,7a-tetrahydrocyclo-penta[c]pyran-4-carboxylate

Genipin (1 equivalent) was added to a round bottom flask and dissolved with benzyl alcohol/dichloromethane (1/1 v/v) (0.5 M). Dowex® 50WX8 (20 wt %) was added to the stirring solution of genipin and allowed to react at 40 °C until complete conversion of starting material. Once complete, the crude material was filtered to remove the Dowex® resin and then concentrated via rotary evaporation. The title compound was isolated via flash column chromatography.

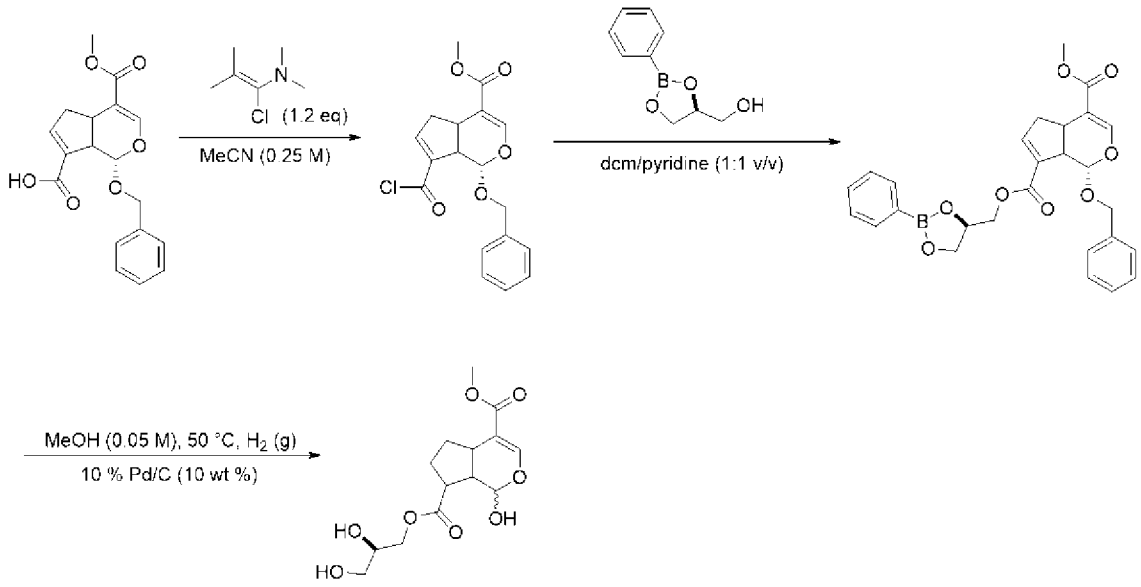
Step 2: Oxidation of o-benzyl protected genipin: benzyl 7-formyl-1-methoxy-1,4a,5,7a-tetrahydrocyclopenta[c]pyran-4-carboxylate

To a stirring solution of benzyl-protected genipin in acetonitrile (0.5 M) was added 20 mol % of CuBr, 2,2'-bipyridyl, and TEMPO catalyst species. The contents were stirred vigorously in an open-to-air flask until complete conversion of starting material. The title compound was isolated via flash column chromatography.

Step 3: Oxidation to carboxylic acid

The product of step 2 was dissolved in dimethylformamide (0.2 M) and stirred with 4 equivalents of potassium peroxymonosulfate for 48 hours. The crude material was added to a separatory funnel with ethyl acetate and washed with brine (3x). The aqueous phase

was then back-extracted with ethyl acetate (3x). The combined ethyl acetate was dried with sodium sulfate and concentrated before isolation via flash column chromatography to give the title compound.

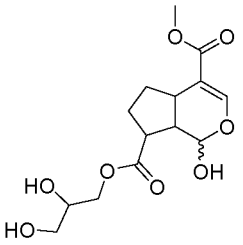


Step 1: Acylation of genipin carboxylate derivative

To a solution of the carboxylic acid in dry MeCN (0.25 M) was added 1-chloro-N,N-2-trimethyl-1-propenylamine (1.2 eq) at 0 °C and stirred for 1 h while warming to room temperature. Once the starting material was consumed (verified by TLC), the mixture was concentrated to an oil under vacuum. Once concentrated, dry dichloromethane (0.2 M) was added to the reaction mixture and stirred at 0 °C. To this was added the glycerol-phenylboronic ester, and then pyridine (equal volume to dichloromethane). The ice bath was removed, and the mixture was allowed to warm to room temperature for 1 hour. Once complete the reaction was diluted with DCM and transferred to a separatory funnel. Wash with 1 M HCl (2X) to remove pyridine. The DCM was concentrated and resuspended in ethyl acetate before being washed with 1 M D-sorbitol/1M Na_2CO_3 (3X) to cleave the boronic ester and remove phenylboronic acid. The combined aqueous phases were back-extracted with ethyl acetate, dried with sodium sulfate and concentrated to dryness. The resultant crude material was purified via flash column chromatography using a gradient of ethyl acetate and pentane.

Step 2: Reduction and deprotection of acylated genipin derivative

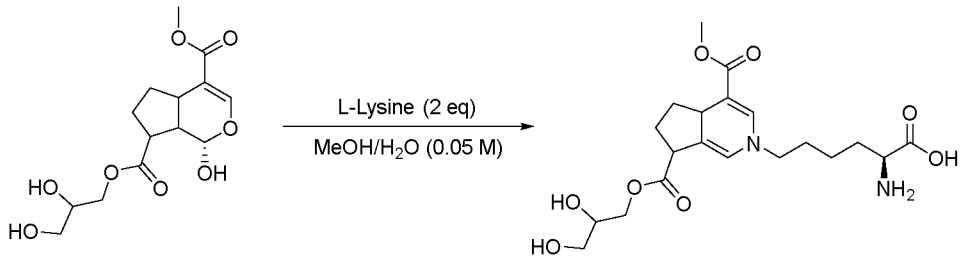
10 % Palladium on carbon (10 wt %) was weighed into an oven dried Schlenk flask. The flask was cycled between argon and vacuum 3 times. In a separate Erlenmeyer flask was added methanol equipped with a stir bar. A needle connected to a hose on the argon line was submerged into the methanol and bubbled through the solvent for 15 minutes. Meanwhile, the ester material was weighed into a vial. Once the methanol sparge was complete, the ester starting material was dissolved in degassed methanol. This solution is carefully added to the Schlenk flask under a flow of argon. Once complete, a rubber septum was placed on the Schlenk flask and evacuated under vacuum, then left under static vacuum. A balloon was filled with H_2 and equipped with an 18 G needle. The balloon was added to the reaction flask, warmed to 50 °C, and allowed to react for 24 hours. The crude reaction was purified via flash column chromatography using a gradient of dichloromethane and methanol.



1H NMR (400 MHz, MeOD) *major diastereomer* δ 7.48 (s, 1H), 4.89 (d, J = 7.8 Hz, 1H), 4.23–4.06 (m, 2H), 3.84 (m, 1H), 3.70 (s, 3H), 3.69–3.62 (m, 1H), 3.56 (dd, J = 5.5, 2.1 Hz, 2H), 2.89 (m, 2H), 2.38 (m, 1H), 2.32–2.18 (m, 1H), 2.05 (m, 1H), 1.84 (m, 1H), 1.41 (m, 1H).

^{13}C NMR (101 MHz, MeOD) *major diastereomer* δ 177.0, 169.6, 154.2, 110.9, 96.2, 71.1, 66.8, 64.0, 51.7, 46.8, 46.6, 36.9, 33.9, 29.4.

HRMS (DART+): calculated for $C_{14}H_{24}NO_8$ [M+NH_4+]: 334.1496 m/z, found: 334.1503 m/z



The deprotected species from the previous step was reacted with L-lysine (2 molar equivalents) in MeOH (0.05 M) with a few drops of water and stirred for 18 hours at 35 °C.

HRMS (ESI+): $C_{20}H_{31}N_2O_8$ [M+H+]: 427.2075 m/z

As shown in Fig. 6, the obtained lysine conjugate was nearly colorless (very pale yellow).

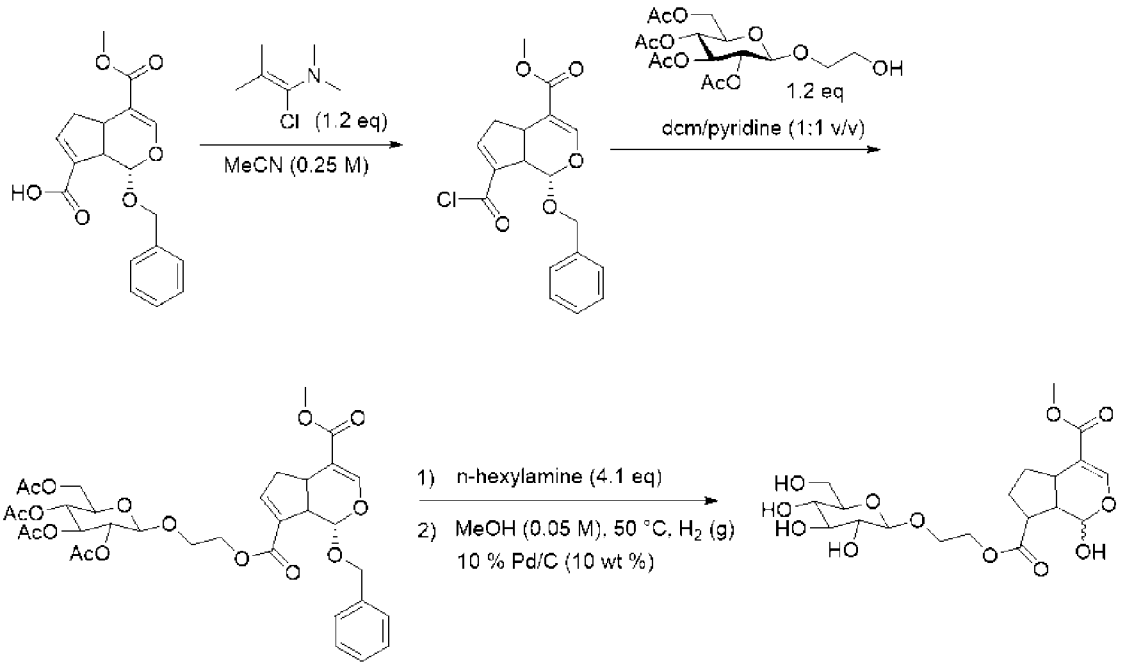
Example 11 – Conjugation of the Compound of Example 10 to skin

100 mM methanolic solutions of the hydrogenated genipin derivatives obtained in Examples 9 and 10 were prepared and 200 µl of each solution was drop-casted onto explanted pig skin. Methanol was applied on a third spot as control. The hydrogenated genipin derivatives were allowed to bind to the skin for 2 hours in a hydrated chamber. The piece of pig skin was then removed from the chamber and thoroughly washed with water to remove any residual unreacted genipin derivative.

As shown in Fig. 7, the pig skin was visually unchanged in normal daylight, but exposure to UV light revealed that the hydrogenated genipin derivatives had coupled to the skin.

Since skin is a keratinous material similar to hair, this experiment also demonstrates that reliable bonding of the compounds of the present disclosure to hair can be expected.

Example 12 – Preparation of a hydrogenated genipin derivative linked to D-glucose with an ethylene glycol linker and its conjugation to lysine



Steps 1 and 2: Acylation of genipin carboxylate derivative:

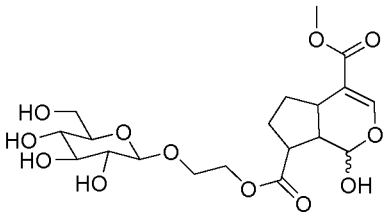
To a solution of the carboxylic acid in dry MeCN (0.25 M) was added 1-chloro-N,N-2-trimethyl-1-propenylamine (1.2 eq) at 0 °C for 1 h. Once the starting material was consumed (verified by TLC), the mixture was concentrated to an oil under vacuum. Once concentrated, dry dichloromethane (0.2 M) was added to the reaction mixture and stirred at 0 °C. To this, was added the glucose derivative (shown above), and then pyridine (equal volume to dichloromethane) (0.2M). The ice bath was removed, and the mixture was allowed to warm to room temperature for 1 hour. Once complete the reaction was diluted with DCM and transferred to a separatory funnel. Wash with 1 M HCl (2X) to remove pyridine. Wash with saturated $NaHCO_3$ (1X) to remove unreacted acyl chloride. Dry with sodium sulfate and concentrate to dryness. The resultant material was purified via flash column chromatography using a gradient of ethyl acetate and pentane.

Step 3: Selective deprotection of acetyl protecting groups

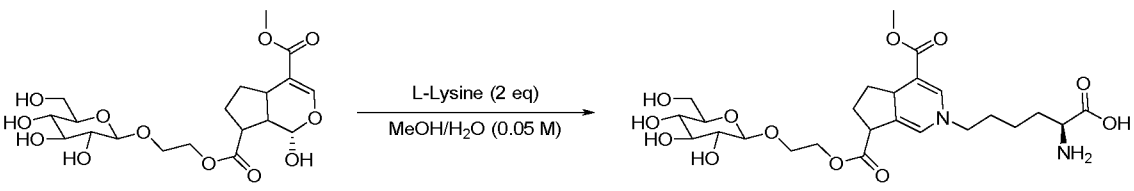
The acetyl-protected product from *Step 2* was selectively deprotected by dissolving in methanol (0.2 M), and then adding 4.1 equivalents of n-hexylamine stirring for 2 h at 50 °C. The resulting deprotected product was isolated via flash column chromatography using a gradient of methanol and dichloromethane.

Step 4: Reduction and deprotection of acylated genipin derivative

10 % Palladium on carbon (10 wt %) was weighed into an oven dried Schlenk flask. The flask was cycled between argon and vacuum 3 times. In a separate Erlenmeyer flask was added methanol equipped with a stir bar. A needle connected to a hose on the argon line was submerged into the methanol and bubbled through the solvent for 15 minutes. Meanwhile, the ester material was weighed into a vial. Once the methanol sparge was complete, the ester starting material was dissolved in degassed methanol. This solution is carefully added to the Schlenk flask under a flow of argon. Once complete, a rubber septum was placed on the Schlenk flask and evacuated under vacuum, then left under static vacuum. A balloon was filled with H_2 and equipped with an 18 G needle. The balloon was added to the reaction flask, warmed to 50 °C, and allowed to react for 24 hours. The crude reaction was purified via flash column chromatography using a gradient of methanol and dichloromethane.



HRMS (ESI+): calculated for $C_{19}H_{28}O_{12}Na$ [M+Na+]: 471.1473 m/z, found: 471.1470 m/z



The deprotected species from the previous step was reacted with L-lysine (2 molar equivalents) in MeOH (0.05 M) with a few drops of water and stirred for 18 hours at 35 °C.

HRMS (DART+): calculated for $C_{25}H_{38}N_2O_{12}$ [M+H+]: 559.2498 m/z, found: 559.2508 m/z

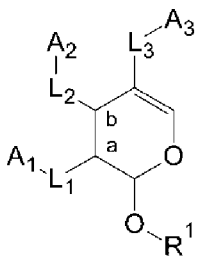
The obtained lysine conjugate was nearly colorless (very pale yellow).

OTHER EMBODIMENTS

It is to be understood that while the present application has been described in conjunction with the detailed description thereof, the description is intended to illustrate and not limit the scope of the present application, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims.

The present disclosure also relates to the following embodiments which are supplementary to and freely combinable with the above specification:

1. A hair care composition comprising a compound capable of covalently binding to hair and an excipient suitable for administration to hair, wherein the compound capable of covalently binding to hair is a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I);

wherein R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the hair care composition onto hair;
wherein L_1, L_2 and L_3 independently from each other represent a linker group or are absent,
wherein A_1, A_2 and A_3 independently from each other represent:

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);
wherein the C_1-C_{60} moiety or the polymeric moiety of group b) is:

b1) configured to act as a moisturizer, a cosmetic hair coating, or a primer for attaching dyes to the hair; and/or

b2) configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety; and

wherein L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively.

2. The hair care composition according to embodiment 1, wherein the C_1-C_{60} moiety or the polymeric moiety of group b) comprises a functional group which couples the moiety to the corresponding L_1, L_2 or L_3 moiety or, if the corresponding L_1, L_2 or L_3 moiety is absent, to the 3,4-dihydro-2H-pyran moiety.

3. The hair care composition according to embodiment 2, wherein the functional group comprises a carbon atom, an oxygen atom, a nitrogen atom, a sulfur atom, a phosphorus atom, or a combination thereof; more specifically a carbon atom, an oxygen atom, a nitrogen atom, or a combination thereof; and in particular a carbon atom and/or an oxygen atom.

4. The hair care composition according to embodiment 3, wherein the functional group comprises one or more of, two or more of, three or more of, four or more of, or all of:

1 and 12 carbon atoms, more specifically between 1 and 6 carbon atoms, and in particular between 1 and 3 carbon atoms;
1 and 12 oxygen atoms, more specifically between 1 and 6 oxygen atoms, and in particular between 1 and 3 oxygen atoms;
1 and 4 nitrogen atoms, more specifically between 1 and 3 nitrogen atoms, and in particular between 1 and 2 nitrogen atoms;
1 and 3 sulfur atoms, more specifically between 1 and 2 sulfur atoms, and in particular 1 sulfur atom;
1 and 3 phosphorus atoms, more specifically between 1 and 2 phosphorus atoms, and in particular 1 phosphorus atom.

5. The hair care composition according to any one of embodiments 2 to 4, wherein the functional group is cleavable under physiological conditions after application of the hair care composition onto hair.

6. The hair care composition according to any one of embodiments 2 to 5, wherein the functional group is hydrolysable at the physiological pH of mammal hair, more specifically of human hair, and in particular at a pH of between about 4 to about 6.

7. The hair care composition according to any one of embodiments 2 to 6, wherein the functional group is enzymatically cleavable under physiological conditions after application of the hair care composition onto hair, in particular enzymatically cleavable by enzymes present on the human hair.

8. The hair care composition according to any one of embodiments 2 to 7, wherein the functional group is configured to be cleaved to a hydroxyl group, a primary or secondary amine group, a carboxylic acid, a thiol, an aldehyde, a ketone, a thiocarbonic acid, a sulfonic acid, a sulfinic acid, a phosphoric acid, a phosphonic acid, an olefin, an olefine, or an oxime; or salts thereof.

9. The hair care composition according to any one of embodiments 2 to 8, wherein the functional group is configured to provide a hydroxyl group, a primary or secondary amine group, a carboxylic acid, a thiol, an aldehyde, a ketone, a thiocarbonic acid, a sulfonic acid, a sulfinic acid, a phosphoric acid, a phosphonic acid, an olefin, an olefine, or an oxime; or salts thereof; on the corresponding L_1, L_2 or L_3 moiety which is attached to the C_1-C_{60} moiety of group b) or, if the corresponding L_1, L_2 or L_3 moiety is absent, on the 3,4-dihydro-2H-pyran moiety after cleaving.

10. The hair care composition according to any one of embodiments 2 to 8, wherein the functional group is configured to provide a hydroxyl group, a primary or secondary amine group, a carboxylic acid, a thiol, an aldehyde, a ketone, a thiocarbonic acid, a sulfonic acid, a sulfinic acid, a phosphoric acid, a phosphonic acid, an olefine, or an oxime; or salts thereof; on the C_1-C_{60} moiety or the polymeric moiety of group b) after cleaving.

11. The hair care composition according to any one of embodiments 2 to 10, wherein the functional group comprises a carbon ester, in particular a monoester, 1,1-diester, a carbonate, or a carbamate; an ether or thioether, in particular an acetal, a hemi-acetal, a glycosidic group or a thioacetal; a carbon amide, in particular a peptide or a N-Mannich base; an enol; an enamine; an imine; an oxime; a sulfate ester; a sulfonic acid ester; a sulfonic acid amid; a phosphoric acid ester; a phosphonic acid ester; a phosphoric acid amide; or a phosphonic acid amide.

12. The hair care composition according to any one of embodiments 2 to 11, wherein A_1 represents a C_1-C_{60} moiety or a polymeric moiety of group b).

13. The hair care composition according to any one of embodiments 2 to 12, wherein A_2 represents a C_1-C_{60} moiety or a polymeric moiety of group b).

14. The hair care composition according to any one of embodiments 2 to 13, wherein A_3 represents a C_1-C_{60} moiety or a polymeric moiety of group b).

15. The hair care composition according to any one of embodiments 12 to 14, wherein the remainder of A_1, A_2 and A_3 represents a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen of group a).

16. The hair care composition according to any one of embodiments 1 to 15, wherein:
L_1 is present and represents an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms; and/or
L_2 is present and represents an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms; and/or
L_3 is present and represents an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms.

17. The hair care composition according to any one of embodiments 2 to 15, wherein:
L_1 is present and represents an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms and wherein the functional group is attached to L_1; and/or
L_2 is present and represents an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms and wherein the functional group is attached to L_2; and/or
L_3 is present and represents an optionally substituted hydrocarbon moiety comprising, in combination with its optional substituents, 1 to 8 carbon atoms and wherein the functional group is attached to L_3.

18. The hair care composition according to any one of embodiments 1 to 17, wherein L_1 and L_2 are present and form a 5-, 6-, 7- or 8-membered ring, in particular a cyclopentyl, a cyclohexyl, a pyrrolidinyl, a piperidinyl, a tetrahydrofuranyl or a tetrahydropyranyl.

19. The hair care composition according to embodiment 18, wherein L_1 and L_2 are present and form an optionally substituted 5-or 6-membered ring, in particular cyclopentyl or cyclohexyl, to which A_1 and A_2 are attached, optionally via a group selected from: -O-,

-S-, -C(O)-, -CO_2-, -O-C(O)-, -NH-C(O)-, -C(O)-NH-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O- and -O-$(CH_2)_{1-4}$-, or combinations thereof.

20. The hair care composition according to embodiment 18, wherein L_1 and L_2 are present and form a cyclopentyl, a cyclopentenyl, a cyclohexyl, or a cyclohexenyl ring to which A_1 and A_2 are attached, optionally via a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NH-C(O)-, -C(O)-NH-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O- and -O-$(CH_2)_{1-4}$-, or combinations thereof.

21. The hair care composition according to embodiment 20, wherein A_1 is a C_1-C_{60} moiety or a polymeric moiety of group b).

22. The hair care composition according to embodiment 20 or embodiment 21, wherein A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b).

23. The hair care composition according to embodiment 21 or embodiment 22, wherein A_2 represents a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen of group a), in particular hydrogen.

24. The hair care composition according to any one of embodiments 1 to 23, wherein the C_1-C_{30} moiety of group a) comprises 1 to 30, more specifically 1 to 16, and in particular 1 to 12 carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 phosphorus atoms, and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms.

25. The hair care composition according to embodiment 24, wherein the C_1-C_{30} moiety is selected from a saturated or unsaturated, cyclic or acylic (hetero)alkyl comprising 1 to 30, more specifically 1 to 16, and in particular 1 to 12, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6,

and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms; and/or wherein the C_1-C_{30} moiety is bound to L_1, L_2 and L_3, respectively, via a carbon atom, an oxygen atom, a nitrogen atom or a sulfur atom.

26. The hair care composition according to any preceding embodiment, wherein A_3 represents a C_1-C_{30} moiety of group a), more specifically a C_1-C_{16} moiety selected from a saturated or unsaturated, cyclic or acylic (hetero)alkyl comprising 1 to 16, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 oxygen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 6, more specifically 0 to 4, and in particular 0 to 3 halogen atoms.

27. The hair care composition according to embodiment 26, wherein A_3 represents a C_1-C_{16} moiety selected from a carboxylic acid or a salt thereof; a carboxylic ester; or a ketone.

28. The hair care composition according to embodiment 26, wherein A_3 represents a C_1-C_{16} moiety selected from a carboxylic acid or a salt thereof; a (C_1-C_4-alkyl)carboxylic ester; or a C_1-C_4-alkylcarbonyl.

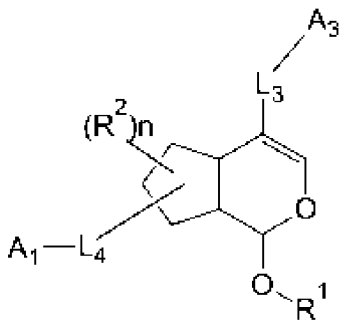
29. The hair care composition according to any preceding embodiment, wherein L_1 and OR^1, together with the carbon atoms to which they are attached, form a 5- or 6-membered lactone.

30. The hair care composition according to any preceding embodiment, wherein R^1 represents hydrogen, C_{1-6} acyl, or C_{1-6} alkyl; and in particular hydrogen.

31. The hair care composition according to any one of embodiments 1 to 30, wherein at least one of A_1, A_2 and A_3 represents a C_1-C_{60} moiety or a polymeric moiety of group b1).

32. The hair care composition according to any one of embodiments 1 to 31, wherein at least one of A_1, A_2 and A_3 represents a C_1-C_{60} moiety or a polymeric moiety of group b2).

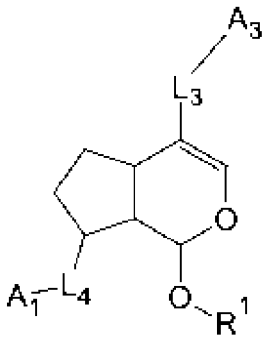
33. The hair care composition according to any one of embodiments 1 to 32, wherein the compound capable for covalently binding to hair is a compound of formula (II), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(II);

wherein R^1, L_3, A_1 and A_3 are as defined in any of embodiments 1 to 32;
wherein $(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;
wherein n is an integer selected from 1 and 2; and
wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O- and -O-$(CH_2)_{1-4}$-; and
wherein R^4 is selected from H or C_1-C_4-alkyl.

34. The hair care composition according to any one of embodiments 1 to 33, wherein the compound capable for covalently binding to hair is a compound of formula (III), or a tautomer and/or a pharmaceutically acceptable salt thereof,



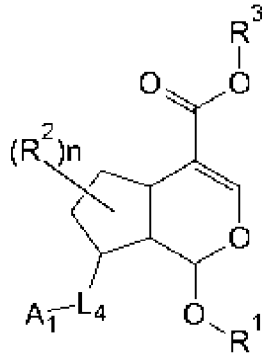
(III);

wherein R^1, L_3, A_1 and A_3 are as defined in any of embodiments 1 to 32; and

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

35. The hair care composition according to any one of embodiments 1 to 33, wherein the compound capable for covalently binding to hair is a compound of formula (IV), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(IV);

wherein R^1 and A_1 are as defined in any of embodiments 1 to 32;

wherein $(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;

wherein n is an integer selected from 1 and 2;

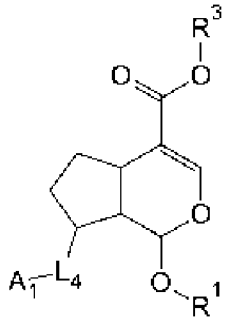
wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof;

wherein R^3 represents hydrogen or an optionally substituted hydrocarbon moiety comprising, in combination with their optional substituents, 1 to 14 carbon atoms; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

36. The hair care composition according to embodiment 35, wherein R^3 represents a C_1-C_4 alkyl moiety or phenyl.

37. The hair care composition according to any one of embodiments 1 to 34, wherein the compound capable for covalently binding to hair is a compound of formula (V), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(V);

wherein R^1 and A_1 are as defined in any of embodiments 1 to 32;

wherein $(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;

wherein n is an integer selected from 1 and 2;

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof;

wherein R^3 is as defined in embodiment 35 or embodiment 36; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

38. The hair care composition according to any one of embodiments 1 to 37, wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety which is configured to act as a moisturizer, and/or which is configured to act as a moisturizer after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

39. The hair care composition according to embodiment 38, wherein the C_1-C_{60} moiety or the polymeric moiety comprises a plurality of hydrogen bonding groups selected from the group consisting of hydroxyl groups, ether groups, carboxylic acids, amines and amides; and their salts.

40. The hair care composition according to embodiment 38 or embodiment 39, wherein the plurality of hydrogen bonding groups comprises three or more, more specifically 4 or more, and in particular 6 or more hydrogen bonding groups.

41. The hair care composition according to embodiment 39 or embodiment 40, wherein the ratio of C-atoms to the sum of hydrogen bonding groups comprised in the C_1-C_{60} moiety or the polymeric moiety is between about 4:1 to 1:1, more specifically between about 3:1 to about 1:1 and in particular between about 2:1 to about 1:1.

42. The hair care composition according to any one of embodiments 38 to 41, wherein the C_1-C_{60} moiety has a molecular weight of at least 60 g/mol, more specifically at least 90 g/mol, and in particular at least 120 g/mol.

43. The hair care composition according to any one of embodiments 38 to 42, wherein the ratio of C-atoms to the sum of heteroatoms comprised in the C_1-C_{60} moiety or the polymeric moiety is between about 4:1 to 1:2, more specifically between about 3:1 to about 1:1.5, and in particular between about 2:1 to about 1:1, wherein the heteroatoms are selected from nitrogen and oxygen.

44. The hair care composition according to any one of embodiments 38 to 43, wherein the C_1-C_{60} moiety or the polymeric moiety comprises:
a polyol, more specifically a polyol having n hydroxyl groups with n being 2 or more, 3 or more, 4 or more, 5 or more, 6 or more, 8 or more, 10 or more, 12 or more, or 16 or more;
a mono- or polyvalent carboxylic acid comprising one or more hydroxyl groups, more specifically glycolic acid, lactic acid, malic acid, tartaric acid or citric acid;
a sugar, more specifically a triose, a tetrose, a pentose a hexose, a monosaccharide, a disaccharide, a trisaccharide, or an oligosaccharide;
a sugar alcohol, more specifically a sugar alcohol comprising between 2 and 24 carbon atoms, in particular ethylene glycol, glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, maltotriitol, or maltotetraitol; or
a sugar acid, more specifically an aldonic acid, an ulosonic acid, an uronic acid or an aldaric acid; or a salt thereof; or an ester thereof, in particular a C_1-C_4-alkylester thereof; or an amide thereof.

45. The hair care composition according to embodiment 44, wherein the C_1-C_{60} moiety has a molecular weight of 60 g/mol to 2000 g/mol, more specifically 90 g/mol to 1600 g/mol, and in particular 120 g/mol to 1200 g/mol.

46. The hair care composition according to any one of embodiments 38 to 45, wherein the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a moisturizer.

47. The hair care composition according to any one of embodiments 38 to 45, wherein the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a moisturizer after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

48. The hair care composition according to any of embodiments 1 to 37, wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b) which is configured to act as a cosmetic hair coating, and/or which is configured to act as a cosmetic hair coating after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

49. The hair care composition according to embodiment 48, wherein the cosmetic hair coating is providing a conditioning effect to the hair.

50. The hair care composition according to embodiment 48 or embodiment 49, wherein the cosmetic hair coating is providing a gloss effect to the hair.

51. The hair care composition according to embodiment 48, embodiment 49 or embodiment 50, wherein the cosmetic hair coating is providing an anti-frizz effect to the hair.

52. The hair care composition according to embodiment 48, embodiment 49, embodiment 50 or embodiment 51, wherein the cosmetic hair coating is providing a reinforcing effect to the hair.

53. The hair care composition according to any one of embodiments 48 to 52, wherein the moiety of group b) is a C_1-C_{60} moiety.

54. The hair care composition according to embodiment 53, wherein the C_1-C_{60} moiety has a molecular weight of 60 g/mol to 2000 g/mol, more specifically 90 g/mol to 1600 g/mol, and in particular 120 g/mol to 1200 g/mol.

55. The hair care composition according to embodiment 53 or embodiment 54, wherein the C_1-C_{60} moiety comprises an aliphatic C_{10}-C_{60} moiety, more specifically a C_{15}-C_{60} aliphatic moiety and in particular C_{20}-C_{60} aliphatic moiety.

56. The hair care composition according to any one of embodiments 53 to 55, wherein the C_1-C_{60} moiety comprises a saturated or unsaturated C_{10}-C_{60} aliphatic moiety, more specifically a C_{15}-C_{60} aliphatic moiety and in particular a C_{20}-C_{60} aliphatic moiety.

57. The hair care composition according to any one of embodiments 53 to 56, wherein the C_1-C_{60} moiety has more than 30 carbon atoms.

58. The hair care composition according to any one of embodiments 48 to 57, wherein the ratio of C-atoms to the sum of heteroatoms comprised in the C_1-C_{60} moiety is between about 60:1 to 1:1, more specifically between about 50:1 to about 5:1 and in particular between about 40:1 to about 10:1, wherein the heteroatoms are selected from nitrogen and oxygen.

59. The hair care composition according to any one of embodiments 48 to 58, wherein the C_1-C_{60} moiety is a sphingosine or a derivative thereof, in particular a ceramide or a sphingomyelin.

60. The hair care composition according to any one of embodiments 48 to 59, wherein the C_1-C_{60} moiety comprises a cation, in particular a quaternary cation.

61. The hair care composition according to embodiment 60, wherein the C_1-C_{60} moiety is positively charged.

62. The hair care composition according to any one of embodiments 48 to 61, wherein the C_1-C_{60} moiety comprises an anion, in particular a sulfate ion or a carboxylate ion.

63. The hair care composition according to embodiment 62, wherein the C_1-C_{60} moiety is negatively charged.

64. The hair care composition according to any of embodiments 48 to 52, wherein the moiety of group b) is a polymeric moiety.

65. The hair care composition according to embodiment 64, wherein the polymeric moiety comprises a cation, in particular a quaternary cation.

66. The hair care composition according to embodiment 65, wherein the polymeric moiety is positively charged.

67. The hair care composition according to embodiment 65 or embodiment 66, wherein the polymeric moiety is a polyquaternium, in particular polyquaternium-16, polyquaternium-46, polyquaternium-11, polyquaternium-28, polyquaternium-6, polyquaternium-7, polyquaternium-22, polyquaternium-39, polyquaternium-2, polyquaternium-17, or polyquaternium-18.

68. The hair care composition according to any one of embodiments 64 to 66, wherein the polymeric moiety comprises an anion, in particular a sulfate ion.

69. The hair care composition according to embodiment 68, wherein the polymeric moiety is negatively charged.

70. The hair care composition according to embodiment 69, wherein the polymeric moiety is a polycarboxylic acid or a polycarboxylate, in particular a polyitaconate.

71. The hair care composition according to embodiment 64, wherein the polymeric moiety comprises a polyether, more specifically a poly-(C_1-C_6)ether, and in particular polymers of ethylene oxide and/or propylene oxide.

72. The hair care composition according to embodiment 64, wherein the polymeric moiety comprises a polysiloxane, more specifically a poly(di-C_1-C_4-alkyl)siloxane and derivatives thereof.

73. The hair care composition according to embodiment 71 and embodiment 72, wherein the polymeric moiety is a copolymer comprising polyether blocks and polysiloxane blocks.

74. The hair care composition according to any one of embodiments 1 to 37, wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b) which is configured to act as a primer for attaching dyes to the hair.

75. The hair care composition according to embodiment 74, wherein the moiety of group b) is a C_1-C_{60} moiety.

76. The hair care composition according to embodiment 75, wherein the C_1-C_{60} moiety has a molecular weight of 60 g/mol to 2000 g/mol, more specifically 90 g/mol to 1600 g/mol, and in particular 120 g/mol to 1200 g/mol.

77. The hair care composition according to any one of embodiments 74 to 76, wherein the moiety which is configured to act as a primer for attaching dyes to the hair comprises hydroxyl groups and/or amino groups.

78. The hair care composition according to embodiment 77, wherein the moiety which is configured to act as a primer for attaching dyes to the hair is configured to react in the presence of an oxidizing agent with a dye precursor under formation of a dye.

79. The hair care composition according to embodiment 78, wherein the moiety which is configured to act as a primer for attaching dyes to the hair is an aromatic moiety comprising two or more functional groups selected from hydroxyls, primary, secondary or tertiary amines, and ethers.

80. The hair care composition according to embodiment 79, wherein the moiety which is configured to act as a primer for attaching dyes to the hair is selected from resorcinol, m-aminophenol, 2-methyl-5-aminophenol, p-phenylenediamine, 2,4-diaminoanisole, 1,5-dihydroxynaphthalene, 4-methoxy-3-aminophenol, 2,4-diaminophenoxyethanol, m-diethylaminophenol and p-amino-o-cresol; and derivatives thereof.

81. The hair care composition according to any one of embodiments 78 to 80, wherein the dye precursor is selected from para-phenylenediamine and para-aminophenol.

82. The hair care composition according to any one of embodiments 78 to 80, wherein the oxidizing agent is a peroxide, in particular hydrogen peroxide.

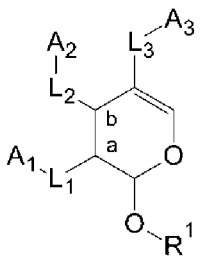
83. The hair care composition according to any one of embodiments 1 to 37, wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety of group b) which is configured to act as a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety.

84. The hair care composition according to embodiment 83, wherein the C_1-C_{60} moiety comprises a functional group which couples the C_1-C_{60} moiety to the corresponding L_1, L_2 or L_3 moiety or, if the corresponding L_1, L_2 or L_3 moiety is absent, to the 3,4-dihydro-2H-pyran moiety, and which is configured to be cleaved to an aldehyde, a ketone, a thiol, a hydroxy or an amine.

85. The hair care composition according to embodiment 84, wherein the functional group is an imine, an acetal, a 1,1-diester, an enolether, an ester, an amide, a thioester, or a thioacetal.

86. The hair care composition according to any one of embodiments 83 to 85, wherein the C_1-C_{60} moiety has a molecular mass after being cleaved off of less than 400 g/mol, more specifically less than 300 g/mol, and in particular less than 200 g/mol.

87. Use of compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety ;

at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

the C_1-C_{60} moiety or the polymeric moiety of group b) is

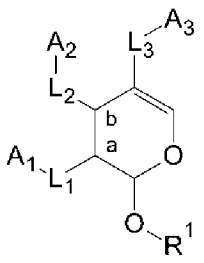
b1) configured to act as a moisturizer or a cosmetic hair coating; and/or

b2) configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety; and

L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively;

for providing a cosmetic effect to hair, more specifically to provide a moisturizing effect, a conditioning effect, a gloss effect, an anti-frizz effect, and/or an olfactory effect to hair.

88. Method of coloring hair, the method comprising applying a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof, to hair;



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a primer for attaching dyes to the hair; and

L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively; and followed by contacting the primed hair with a dye, a pigment, a precursor of a dye, or a precursor of a pigment to effect a covalent attachment of a dye or a pigment to hair.

89. A compound as disclosed in any one of embodiments 1 to 87.

90. The composition or compound according to any preceding claim, wherein R^3 represents a C_1-C_{14} moiety comprising 1 to 14, more specifically 1 to 12, and in particular 1 to 8, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms.

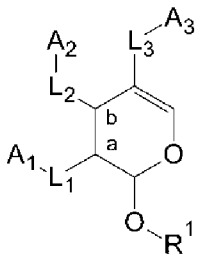
91. The composition or compound according to any preceding claim, wherein R^3 represents C_{1-14} alkyl, C_{2-14} alkenylene, C_{2-14} alkynylene, C_{6-14} aryl, C_{4-14} heteroaryl comprising 1-4 nitrogen atoms, 1-3 oxygen atoms and/or 1-2 sulfur atoms, wherein any of the aforementioned groups is optionally further substituted with the proviso that the aforementioned total sum of the elements recited for R^3 is not exceeded.

92. The composition or compound according to any preceding claim, wherein R^3 represents an optionally substituted phenyl, in particular an optionally substituted phenyl, in particular an optionally substituted phenyl comprising 6 to 14, more specifically 6 to 12, and in particular 6 to 10, carbon atoms; 0 to 12, more specifically 0 to 8, and in particular 0 to 6 oxygen atoms; 0 to 8, more specifically 0 to 6, and in particular 0 to 4 nitrogen atoms; 0 to 6, more specifically 0 to 4, and in particular 0 to 3 sulfur atoms; and 0 to 10, more specifically 0 to 8, and in particular 0 to 6 halogen atoms.

93. The composition or compound according to any one of claims 90 to 92, wherein R^3 is substituted with one or more moieties selected from the group consisting of: -C_{1-4} alkyl, -O-C_{1-4} alkyl, -S-C_{1-4} alkyl, -NH-C_{1-4} alkyl, -N(C_{1-4} alkyl)$_2$, -C(O)C_{1-4} alkyl, -CO_2C_{1-4} alkyl, -O_2C-C_{1-4} alkyl, -C(O)NH-C_{1-4} alkyl, -C(O)N(C_{1-4} alkyl)$_2$, -NH-C(O)C_{1-4} alkyl, -N(C_{1-4} alkyl)-C(O)C_{1-4} alkyl, -SO_3H, -NO_2, -NH_2, -OH, -SH, -COOH, -C(O)H, halogen, in particular Cl, Br or F; and -CF_3.

WHAT IS CLAIMED IS:

1. A hair care composition comprising a compound capable of covalently binding to hair and an excipient suitable for administration to hair, wherein the compound capable of covalently binding to hair is a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I);

wherein R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the hair care composition onto hair;

wherein L_1, L_2 and L_3 independently from each other represent a linker group or are absent,

wherein A_1, A_2 and A_3 independently from each other represent:

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

wherein the C_1-C_{60} moiety or a polymeric moiety of group b) is:

b1) configured to act as a moisturizer, a cosmetic hair coating, or a primer for attaching dyes to the hair; and/or

b2) configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety; and

wherein L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked “a” and “b”, respectively.

2. The hair care composition according to claim 1, wherein the C_1-C_{60} moiety or the polymeric moiety of group b) comprises a functional group which couples the moiety to the corresponding L_1, L_2 or L_3 moiety or, if the corresponding L_1, L_2 or L_3 moiety is absent, to the 3,4-dihydro-2H-pyran moiety.

3. The hair care composition according to claim 2, wherein the functional group is cleavable under physiological conditions after application of the hair care composition onto hair.

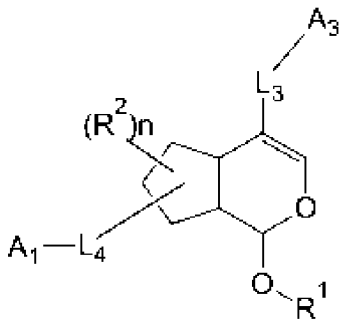
4. The hair care composition according to any one of claims 2 or 3, wherein the functional group is hydrolysable at the physiological pH of mammal hair, more specifically of human hair, and in particular at a pH of between about 4 to about 6; and/or wherein the functional group is enzymatically cleavable under physiological conditions after application of the hair care composition onto hair, in particular enzymatically cleavable by enzymes present on the human hair.

5. The hair care composition according to any one of claims 2 to 4, wherein the functional group comprises a carbon ester, in particular a monoester, 1,1-diester, a carbonate, or a carbamate; an ether or thioether, in particular an acetal, a hemi-acetal, a glycosidic group or a thioacetal; an carbon amide, in particular a peptide or a N-Mannich base; an enol; an enamine; an imine; an oxime; a sulfate ester; a sulfonic acid ester; a sulfonic acid amid; a phosphoric acid ester; a phosphonic acid ester; a phosphoric acid amide; or a phosphonic acid amide.

6. The hair care composition according to any one of claims 1 to 5, wherein A_1 represents the C_1-C_{60} moiety or the polymeric moiety of group b) and wherein A_2 and A_3 independently from each other represent a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen.

7. The hair care composition according to any one of claims 1 to 6, wherein L_1 and L_2 are present and form an optionally substituted 5-or 6-membered ring, in particular cyclopentyl or cyclohexyl, to which A_1 and A_2 are attached, optionally via a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NH-C(O)-, -C(O)-NH-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O- and -O-$(CH_2)_{1-4}$-, or combinations thereof.

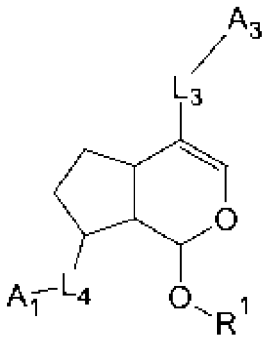
8. The hair care composition according to any one of claims 1 to 7, wherein the compound capable for covalently binding to hair is a compound of formula (II), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(II);

wherein R^1, L_3, A_1 and A_3 are as defined in any of claims 1 to 7;
wherein $(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;
wherein n is an integer selected from 1 and 2; and
wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O- and -O-$(CH_2)_{1-4}$-; and
wherein R^4 is selected from H or C_1-C_4-alkyl.

9. The hair care composition according to any one of claims 1 to 8, wherein the compound capable for covalently binding to hair is a compound of formula (III), or a tautomer and/or a pharmaceutically acceptable salt thereof,



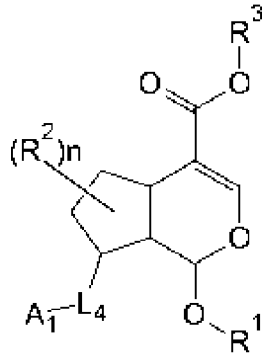
(III);

wherein R^1, L_3, A_1 and A_3 are as defined in any of claims 1 to 32; and

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

10. The hair care composition according to any one of claims 1 to 9, wherein the compound capable for covalently binding to hair is a compound of formula (IV), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(IV);

wherein R^1 and A_1 are as defined in any of claims 1 to 9;

wherein $(R^2)_n$ represents, independently from each other, n moieties selected from H, C_1-C_4 alkyl, C_1-C_4 alkoxyl, hydroxyl, amino, or halogen;

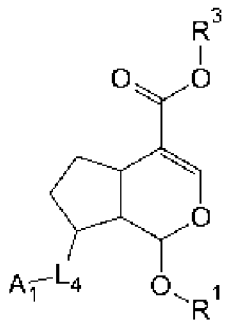
wherein n is an integer selected from 1 and 2;

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof;

wherein R^3 represents hydrogen or an optionally substituted hydrocarbon moiety comprising, in combination with their optional substituents, 1 to 14 carbon atoms; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

11. The hair care composition according to any one of claims 1 to 10, wherein the compound capable for covalently binding to hair is a compound of formula (V), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(V);

wherein R^1 and A_1 are as defined in any of claims 1 to 10;

wherein L_4 is either absent or a group selected from: -O-, -S-, -C(O)-, -CO_2-, -O-C(O)-, -NR^4-, -NR^4-C(O)-, -C(O)-NR^4-, -$(CH_2)_{1-4}$-, -$(CH_2)_{1-4}$-O-, -O-$(CH_2)_{1-4}$-, or combinations thereof;

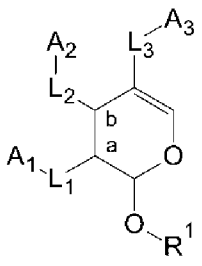
wherein R^3 is as defined in claim 10; and

wherein R^4 is selected from H or C_1-C_4-alkyl.

12. The hair care composition according to any preceding claim, wherein the cosmetic hair coating is providing a conditioning effect to the hair, a gloss effect to the hair, an anti-frizz effect to the hair, and/or a reinforcing effect to the hair.

13. The hair care composition according to any one of claims 1 to 11, wherein at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety which is configured to act as a primer for attaching dyes to the hair, wherein said C_1-C_{60} moiety comprises aromatic hydroxyl groups and/or aromatic amino groups and wherein said C_1-C_{60} moiety or a polymeric moiety is further configured to react in the presence of an oxidizing agent with a dye precursor under formation of a dye.

14. Use of compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof,



(I);

wherein

R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;

L_1, L_2 and L_3 independently from each other represent a linker group or is absent,

A_1, A_2 and A_3 independently from each other represent

a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or

b) a C_1-C_{60} moiety or a polymeric moiety;

at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b);

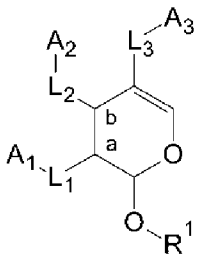
the C_1-C_{60} moiety or the polymeric moiety of group b) is

b1) configured to act as a moisturizer or a cosmetic hair coating; and/or

b2) configured to act as a moisturizer, a cosmetic hair coating or a fragrance after being cleaved off of the 3,4-dihydro-2H-pyran moiety; and

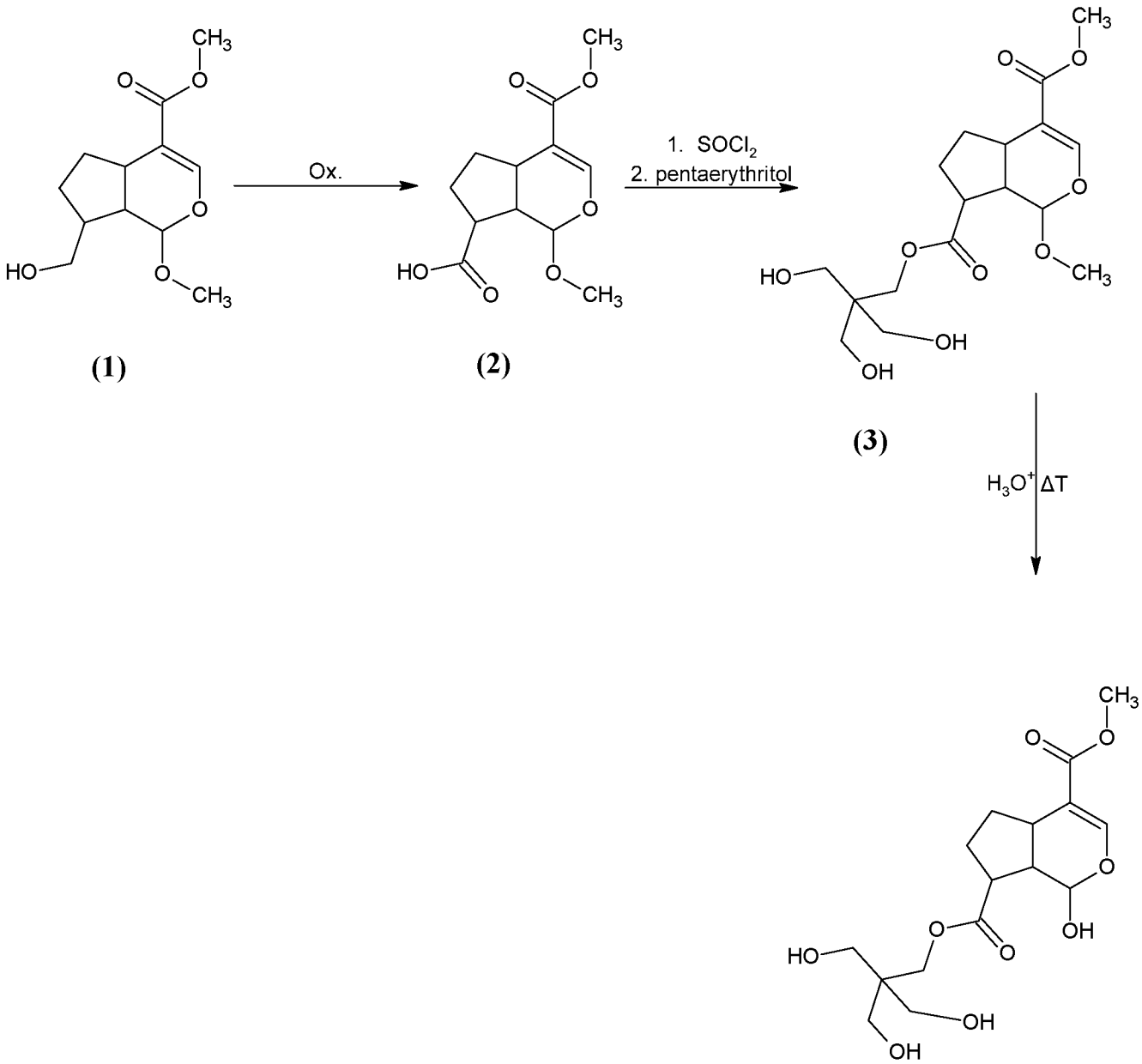
L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked "a" and "b", respectively;
for providing a cosmetic effect to hair, more specifically to provide a moisturizing effect, a conditioning effect, a reinforcing effect, a gloss effect, an anti-frizz effect, and/or an olfactory effect to hair.

15. Method of coloring hair, the method comprising applying a compound of formula (I), or a tautomer and/or a pharmaceutically acceptable salt thereof, to hair;



(I);

wherein
R^1 represents hydrogen or a protective group hydrolysable under physiological conditions after application of the compound onto hair;
L_1, L_2 and L_3 independently from each other represent a linker group or is absent,
A_1, A_2 and A_3 independently from each other represent
a) a C_1-C_{30} moiety, H, hydroxyl, amino, or a halogen, or
b) a C_1-C_{60} moiety or a polymeric moiety;
at least one of A_1, A_2 and A_3 is a C_1-C_{60} moiety or a polymeric moiety of group b), the C_1-C_{60} moiety or the polymeric moiety of group b) is configured to act as a primer for attaching dyes to the hair; and
L_1-A_1 and L_2-A_2 do not represent a moiety comprising an unsaturated C-C or C-N bond in alpha-position to the carbon atom marked "a" and "b", respectively; and
followed by contacting the primed hair with a dye, a pigment, a precursor of a dye, or a precursor of a pigment to effect a covalent attachment of a dye or a pigment to hair.



(1) **(2)** **(3)** **(4)**

Fig. 1

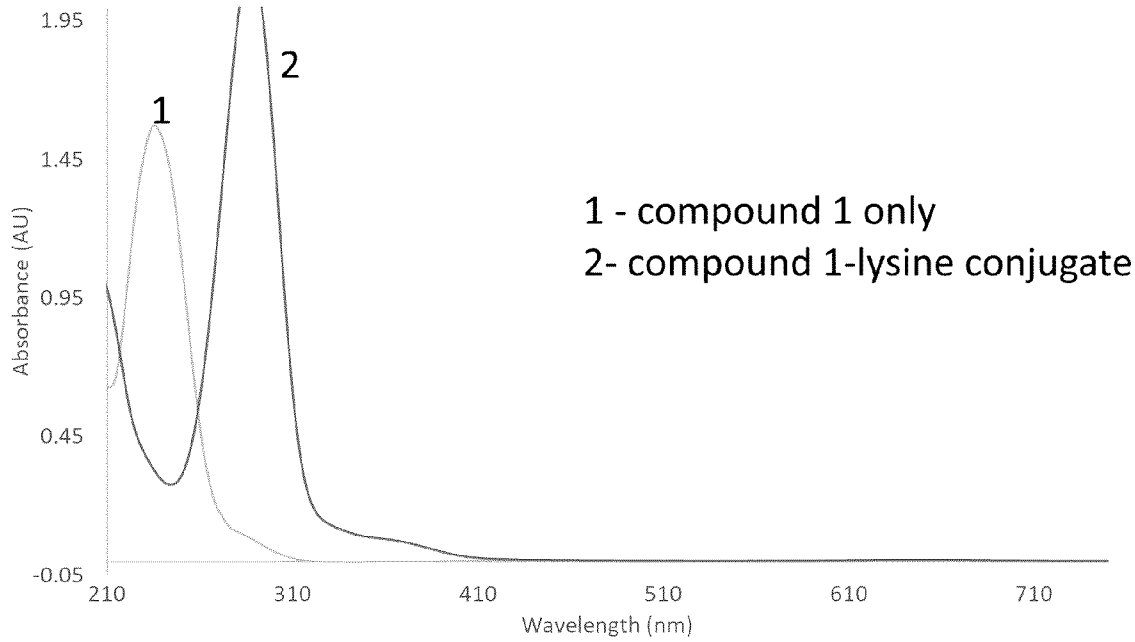

1.95
1.45
0.95
0.45
-0.05
Absorbance (AU)
210
310
410
510
610
710
Wavelength (nm)
1
2
1 - compound 1 only
2- compound 1-lysine conjugate

Fig. 2

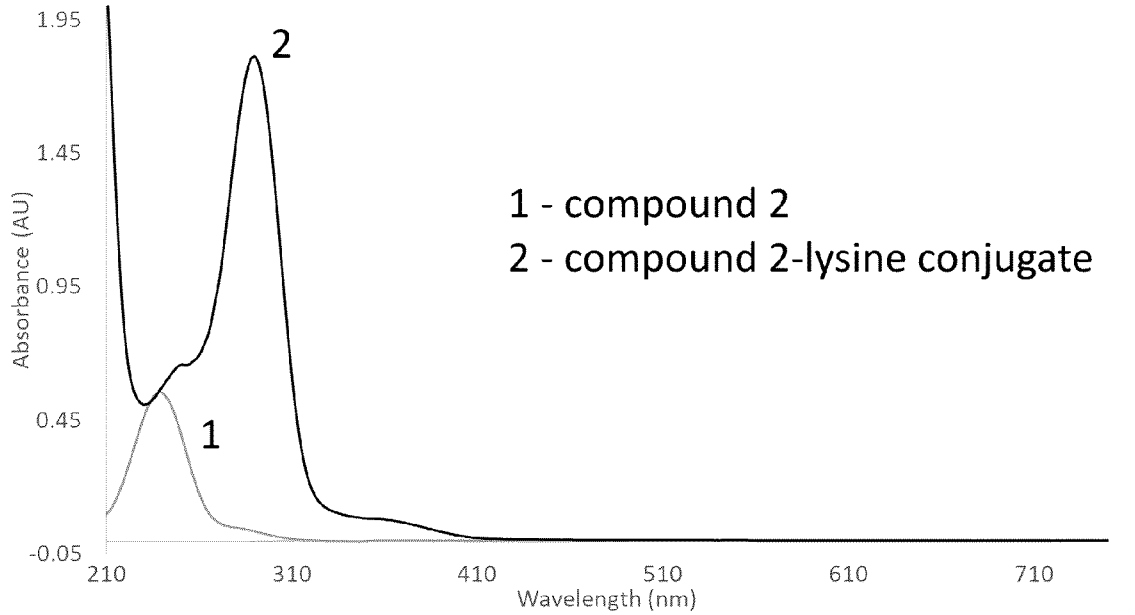

1.95
1.45
0.95
0.45
-0.05
Absorbance (AU)
210
310
410
510
610
710
Wavelength (nm)
2
1
1 - compound 2
2 - compound 2-lysine conjugate

Fig. 3A

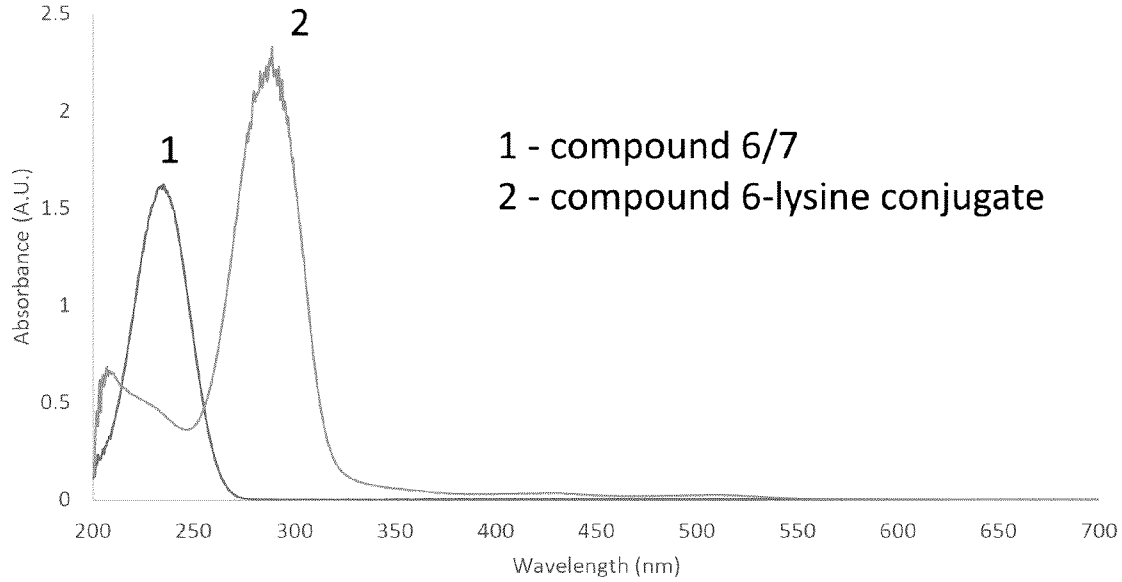

2.5
2
1.5
1
0.5
0
Absorbance (A.U.)
1
2
1 - compound 6/7
2 - compound 6-lysine conjugate
200
250
300
350
400
450
500
550
600
650
700
Wavelength (nm)

Fig. 3B

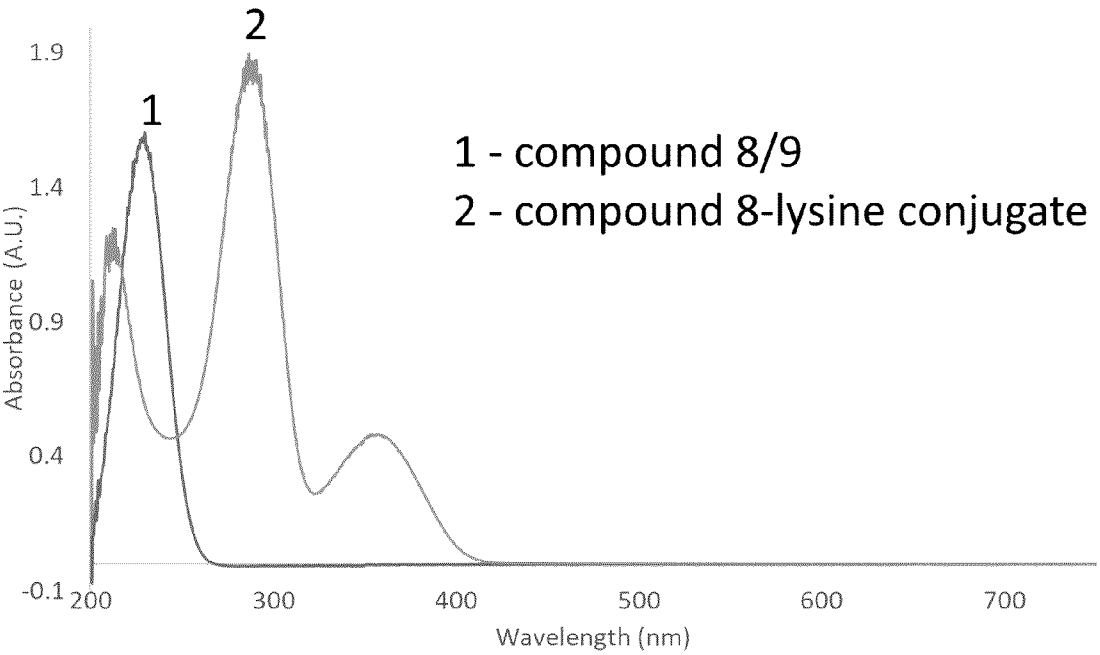

1.9
1.4
0.9
0.4
-0.1
Absorbance (A.U.)
1
2
1 - compound 8/9
2 - compound 8-lysine conjugate
200
300
400
500
600
700
Wavelength (nm)

Fig. 3C

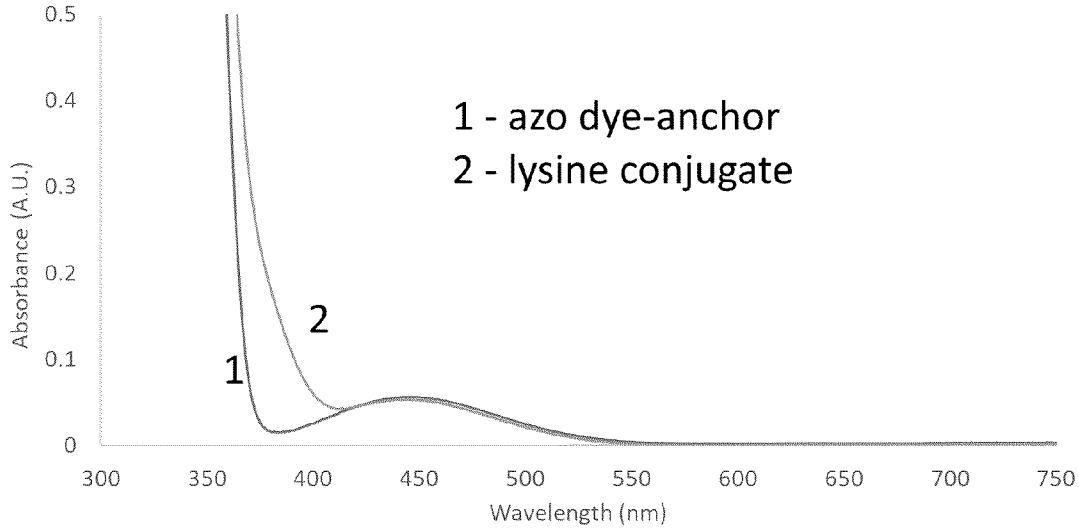

0.5
0.4
0.3
0.2
0.1
0
Absorbance (A.U.)
300
350
400
450
500
550
600
650
700
750
Wavelength (nm)
1 - azo dye-anchor
2 - lysine conjugate
1
2

Fig. 3D

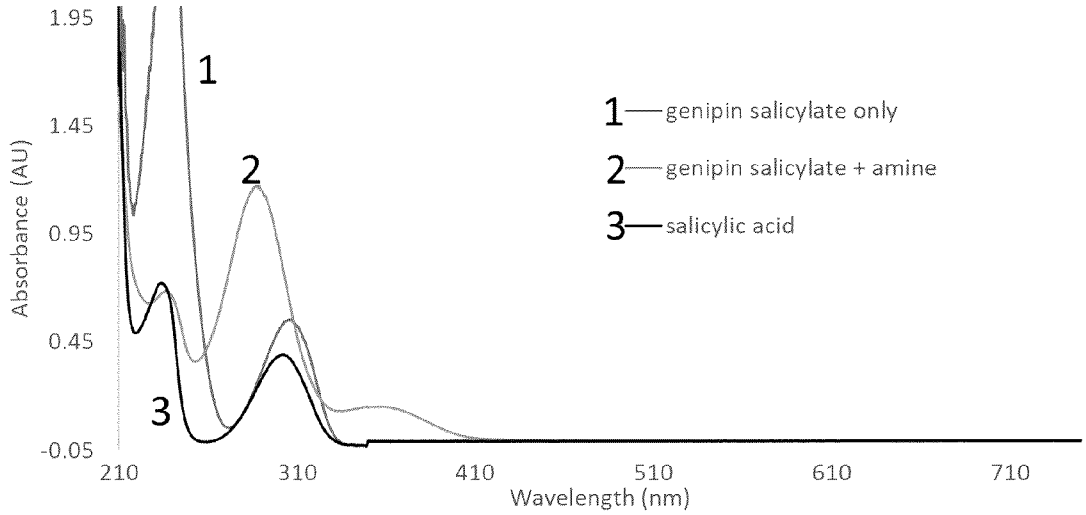

1.95
1.45
0.95
0.45
-0.05
Absorbance (AU)
210
310
410
510
610
710
Wavelength (nm)
1
2
3
1 genipin salicylate only
2 genipin salicylate + amine
3 salicylic acid

Fig. 4

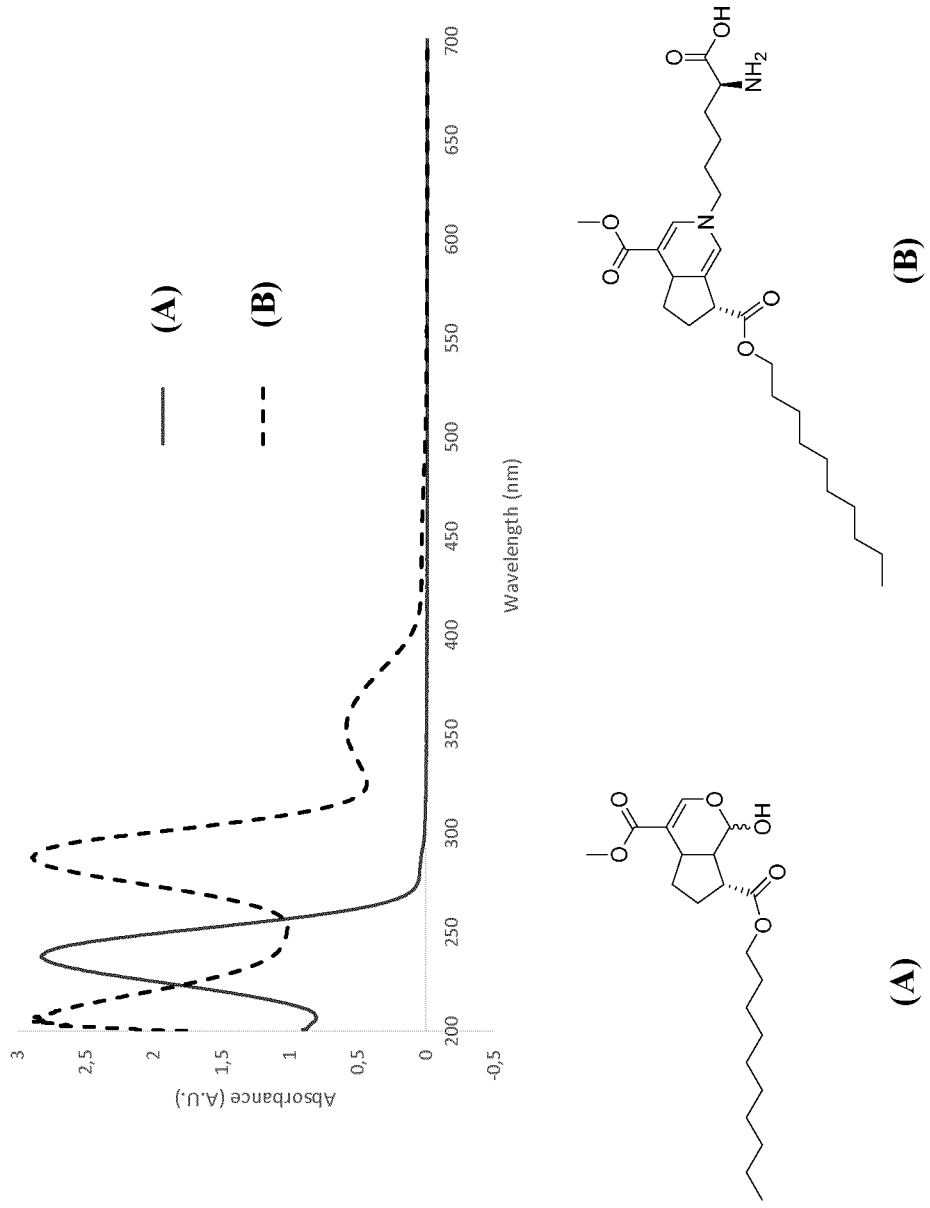

(A)
(B)
Absorbance (A.U.)
Wavelength (nm)
3
2,5
2
1,5
1
0,5
0
-0,5
200
250
300
350
400
450
500
550
600
650
700
OH
O
O
O
O
O
NH2
N
(B)
(A)

Fig. 5

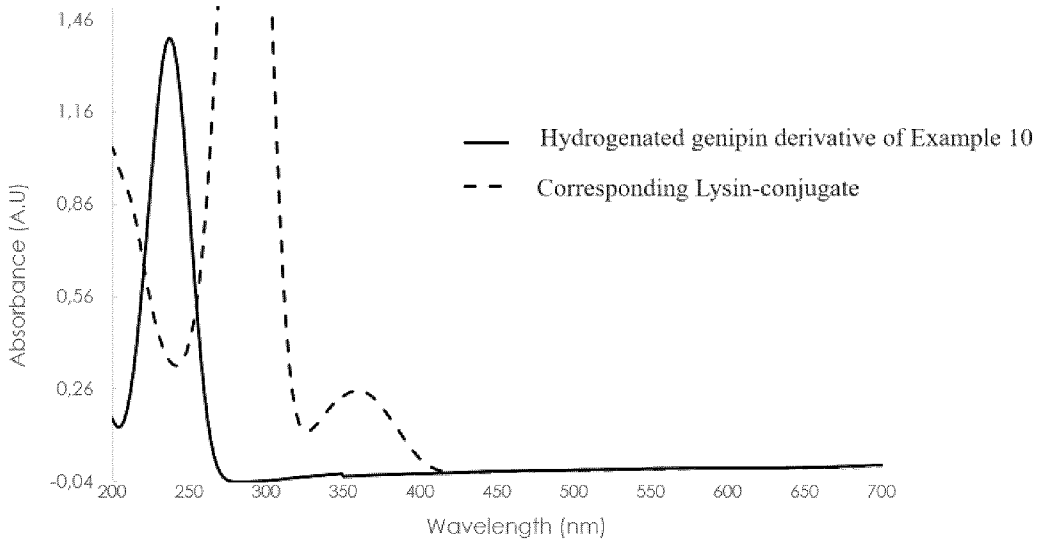

1,46
1,16
0,86
0,56
0,26
-0,04
Absorbance (A.U)
200
250
300
350
400
450
500
550
600
650
700
Wavelength (nm)
Hydrogenated genipin derivative of Example 10
Corresponding Lysin-conjugate

Fig. 6

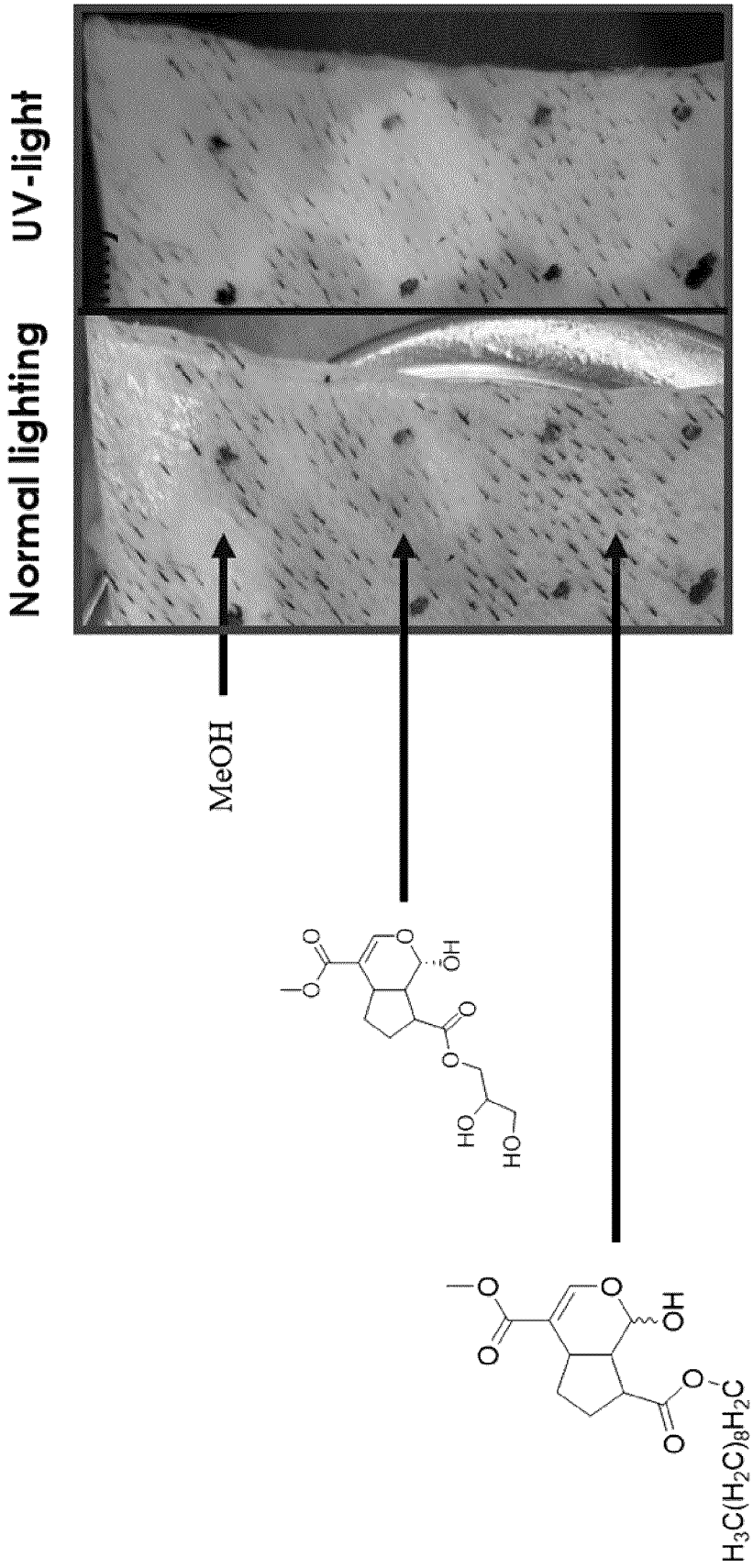

UV-light
Normal lighting
MeOH
OH
HO
HO
OH
O
O
O
O
O
O
O
O
O
$H_3C(H_2C)_8H_2C$

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2024/050764

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***A61K 8/49*** (2006.01), ***A61Q 5/00*** (2006.01), ***A61Q 5/06*** (2006.01), ***C07D 311/94*** (2006.01)

CPC: **A61K 8/498** (2020.01), A61K2800/94 (2020.01), A61K2800/432 (2020.01), A61Q 5/00 (2020.01), A61Q 5/065 (2020.01), C07D 311/94 (2022.08)

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)
IPC: ***A61K 8/49*** (2006.01), ***A61Q 5/00*** (2006.01), ***A61Q 5/06*** (2006.01), ***C07D 311/94*** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel Orbit, STN (Genipin, hair, color, dye)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA2932703A1 (HANDLEY, TYLER J. et al.) 19 December 2016 (19-12-2016)	1-15
A	WO2022045385A1 (SHIN JAE-YOUNG et al.) 3 March 2022 (03-03-2022)	1-15

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

*	Special categories of cited documents:	"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
"A"	document defining the general state of the art which is not considered to be of particular relevance	"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
"D"	document cited by the applicant in the international application	"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
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 06 August 2024 (05-08-2024)	Date of mailing of the international search report 10 September 2024 (10-09-2024)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Michelle Ting (819) 775-7621

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2024/050764

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
CA2932703A1	19 December 2016 (19-12-2016)	CA2932703C	31 December 2019 (31-12-2019)
		CA3006358A1	19 December 2016 (19-12-2016)
		CA3006358C	25 February 2020 (25-02-2020)
		DK3106206T3	03 January 2022 (03-01-2022)
		EP3106206A2	21 December 2016 (21-12-2016)
		EP3106206A3	22 March 2017 (22-03-2017)
		EP3106206B1	29 September 2021 (29-09-2021)
		EP3995179A1	11 May 2022 (11-05-2022)
		EP4218939A1	02 August 2023 (02-08-2023)
		EP4218939B1	24 July 2024 (24-07-2024)
		EP4309640A2	24 January 2024 (24-01-2024)
		EP4309640A3	20 March 2024 (20-03-2024)
		ES2902033T3	24 March 2022 (24-03-2022)
		US2018271764A1	27 September 2018 (27-09-2018)
		US10143641B2	04 December 2018 (04-12-2018)
		US2016367460A1	22 December 2016 (22-12-2016)
		US10500145B2	10 December 2019 (10-12-2019)
		US2018271763A1	27 September 2018 (27-09-2018)
		US11944700B2	02 April 2024 (02-04-2024)
WO2022045385A1	03 March 2022 (03-03-2022)	CN116096344A	09 May 2023 (09-05-2023)
		JP2023547018A	09 November 2023 (09-11-2023)
		KR20230046302A	05 April 2023 (05-04-2023)
		US2023330120A1	19 October 2023 (19-10-2023)