

"Prenylated Hydroxystilbenes"

Cross-Reference to Related Applications

5 The present application claims priority from AU2011901663 the content of which is incorporated herein by reference.

Technical Field

10 This invention relates to novel prenylated stilbene compounds and to the use of such compounds in the treatment of diseases and medical disorders, for example cancer and skin aging.

Background of the Invention

15 Propolis, or so called bee glue, is a complex resinous substance collected by worker honey bees (*Apis mellifera*) from exudates and secretions of young shoots and buds from certain trees and shrubs. It is used by the bees to seal cracks and holes in their hives, and protect against microbial infections.

20 Propolis is a rich source of bioactive substances, and the medicinal use of propolis dates back to ancient civilizations. Currently, propolis is extensively available as a natural health product, and is widely used in cosmetics. However, its modern use in medicine is limited, largely due to the wide variations in chemical compositions arising from honey bees collecting from different or a mixture of plant sources. The composition of propolis is dependent upon the surrounding flora to which the bees have access, and as such, differences in flora may result in differences in propolis
25 compositions. For example, it is known that flavonoids are the major pharmacologically active compounds in European propolis, polyprenylated benzophenones are the main substances in Cuban and Venezuelan propolis, and prenylated cinnamic acid derivatives are predominant in Brazilian propolis.

30 Recognition of the botanical origin of the propolis produced by honey bees enables beehives to be placed in favourable locations such that propolis from a single botanical source may be produced to enable manufacture of medicines of high quality and efficacy.

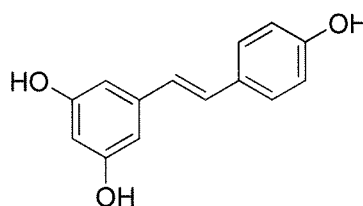
35 The medicinal uniqueness of propolis is determined by the selective collecting ability of honey bees, as they can recognise natural materials that are relatively non-polar and

have antibiotic properties. As reported, the common source of propolis is leaf and flower bud exudates, which are of high antibiotic character in order to protect the delicate growing of plant tissue from attack by microorganisms. It has also been reported that honey bees collect exudates from wounded or diseased plant tissues. Such sources are potentially rich in antibiotic substances produced by plants in response to wounding or attack from insects, microorganisms and viruses.

It is not clear from previous studies whether the bees simply collect a plant material that is known as propolis, or if there is metabolic modification or addition from the bees. However, there does not appear to be evidence of significant amounts of material added from honey bees, or strong evidence for metabolic transformation.

Thus, a better understanding is required regarding the composition of propolis in specific geographical locations to be able to utilize it to its full benefit.

In work leading up to the present invention the inventors have conducted a survey of propolis samples isolated from Kangaroo Island (South Australia), and surprisingly found that unlike other propolis which commonly contain flavonoids as active constituents, Kangaroo Island propolis contain stilbenes, more particularly novel prenylated polyhydroxystilbenes (pPHOS) which are similar in their core structure to resveratrol (pictured below).



Resveratrol

Resveratrol is the constituent in red wine thought to contribute to the low incidence of heart attack amongst the French despite high consumption of very rich food. In fact, Resveratrol has been shown to inhibit LDL oxidation which leads to atherosclerosis and coronary heart disease. Resveratrol is also a lead compound in preventative anti-ageing medicine, and has also been found to possess anti-cancer and antioxidant activities.

However, despite its therapeutic properties, resveratrol exhibits very poor oral bioavailability and is rapidly metabolized in the intestines and liver into glucuronate and sulfate conjugates. The *in vivo* effectiveness of resveratrol is only observed at high concentrations (up to 5 g), or in the case of direct administration such as intravenous or
5 local application.

Recently, GlaxoSmithKline (GSK) Pharmaceutical conducted phase IIa clinical trials of its proprietary formulation of resveratrol (3-5 g), SRT501 in the treatment of multiple myeloma; however, the trials were halted as the formulation only offered
10 minimal efficacy, and several patients in the trial developed kidney failure.

Prenylated hydroxystilbenes have been reported in plants, mainly from the Moraceae (Mulberry family, including *Morus alba* (mulberry), and various *Artocarpus* species) and Fabaceae (Legume family, including *Arachis hypogaea* (peanut)) families. The
15 isolated compounds have reportedly exhibited anti-inflammatory, antimicrobial and antioxidant activities, thus suggesting that the prenyl group does not adversely affect the biological activities of hydroxystilbenes.

In fact, prenylated hydroxystilbenes could circumvent the problem of low
20 bioavailability of hydroxystilbenes, such as resveratrol, due to their lipophilic nature. Owing to the presence of one or more prenyl groups, the compounds may be able to cross cell membranes more readily and the formation of glucuronate and sulfate conjugates may be avoided, thus improving the bioavailability of the compounds, and more generally presenting superior drug candidates for the development of new
25 therapeutic agents. Previously, it has been demonstrated that a tetramethoxy derivative of resveratrol was able to cross the blood-brain barrier in rats more easily than resveratrol.

Thus, the novel pPHOS derivatives isolated from the propolis samples of Kangaroo
30 Island are strong candidates for the development of new therapeutic agents in the treatment of diseases such as cancer.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or
35 all of these matters form part of the prior art base or were common general knowledge

in the field relevant to the present invention as it existed before the priority date of each claim of this application.

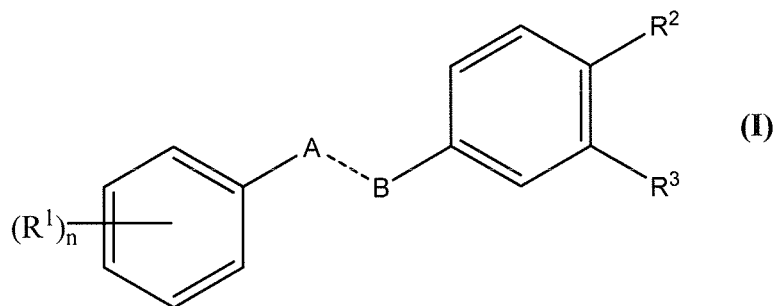
Summary of the Invention

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In work leading up to the present disclosure the inventors have isolated and synthesised a number of novel prenylated polyhydroxystilbenes (pPHOS) derivatives, and carried out *in vitro* experiments in which these novel compounds have exhibited high potency and selectivity in a panel of cancer cell lines, particularly in leukemia and melanoma cell lines. In other preliminary experiments, a number of the novel pPHOS derivatives were found to modulate activity of the SIRT1 enzyme which indicate that the novel pPHOS compounds of the present invention may be lead therapeutic agents for the treatment of a range of diseases.

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15 Accordingly, in a first aspect of the present disclosure, there is provided a method for treating cancer comprising administering a therapeutically effective amount of a compound of formula (I),



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wherein:

R^1 is independently H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$, wherein at least one of R^1 is $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^2 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

25

R^3 is selected from H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

n is an integer selected from the group consisting of 1, 2, 3 or 4;

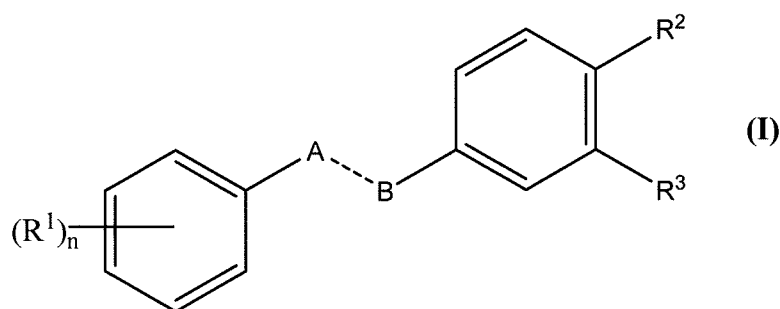
and A---B is selected from $CH=CH$, CH_2-CH_2 , $CH=CHX$, or CH_2-CH_2X ,

where $X=(CH_2)_pCH_2$, and p is an integer selected from the group consisting of 0, 1, 2 or 3; provided that when R^2 is OH, R^3 is H or OH, A---B is $CH=CH$, n is

3 and two of the R^1 groups are OH, then the third R^1 group is not $CH=CHCH(CH_3)_2$;

or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds, to a patient in need thereof.

- 15 In a second aspect of the present disclosure, there is provided a method for treating cancer comprising administering a therapeutically effective amount of a compound of formula (I),



wherein:

R^1 is independently H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$, wherein at least one of R^1 is $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^2 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^3 is selected from H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

n is an integer selected from the group consisting of 1, 2, 3 or 4;

and A---B is selected from $CH=CH$, CH_2-CH_2 , $CH=CHX$, or CH_2-CH_2X , where $X=(CH_2)_pCH_2$, and p is an integer selected from the group consisting of 0, 1, 2 or 3;

or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds, to a patient in need thereof.

In a third aspect, there is provided a compound of formula (I) according to the first or second aspects, or pharmaceutical composition thereof, for use as a medicament.

In a fourth aspect, there is provided a compound of formula (I) according to the first or second aspects, or pharmaceutical composition thereof, for use in therapy.

In a fifth aspect, there is provided a compound of formula (I) according to the first or second aspects, or pharmaceutical composition thereof, for use in the treatment of cancer.

In a sixth aspect, there is provided a method for treating immunosuppression comprising administering a therapeutically effective amount of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition including said compounds to a patient in need thereof.

In a seventh aspect, there is provided a method for treating inflammation comprising administering a therapeutically effective amount of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition including said compounds to a patient in need thereof.

In an eighth aspect, there is provided a method for treating a bacterial or fungal infection comprising administering a therapeutically effective amount of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition including said compounds to a patient in need thereof.

In a ninth aspect, there is provided a method for treating skin aging comprising administering a therapeutically effective amount of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition including said
5 compounds to a patient in need thereof.

In a tenth aspect, there is provided a use of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition thereof in the preparation of a
10 medicament for the treatment of cancer.

In an eleventh aspect, there is provided a use of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition thereof in the preparation of a medicament for the treatment of immunosuppression.

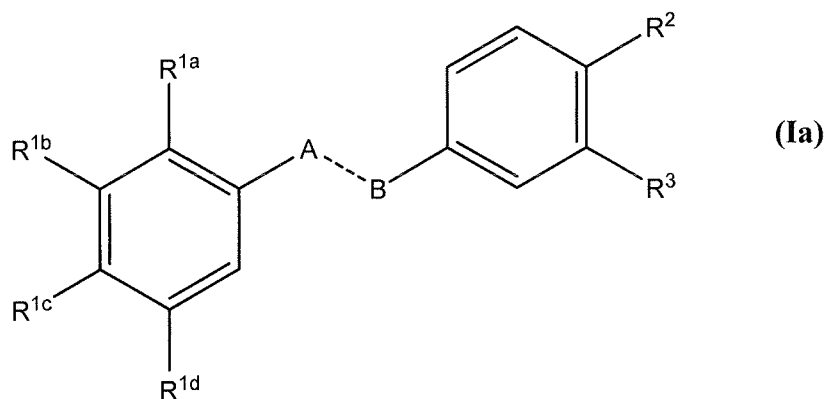
15 In a twelfth aspect, there is provided a use of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition thereof in the preparation of a medicament for the treatment of inflammation.

20 In a thirteenth aspect, there is provided a use of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition thereof in the preparation of a medicament for the treatment of a bacterial or fungal infection.

In a fourteenth aspect, there is provided a use of a compound of formula (I) according to the first or second aspects, or a pharmaceutical composition thereof in the
25 preparation of a medicament for the treatment of skin aging.

In further aspects, there is provided combinations comprising a compound or pharmaceutical composition as defined above, and at least one further therapeutic agent for the methods and uses as described herein.
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According to a fifteenth aspect, there is provided a compound of formula (Ia)



or a pharmaceutically acceptable salt or solvate thereof, wherein:

R^{1a} , R^{1b} , R^{1c} and R^{1d} are each independently H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$, wherein at least one of R^{1a-1d} is $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^2 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^3 is selected from H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

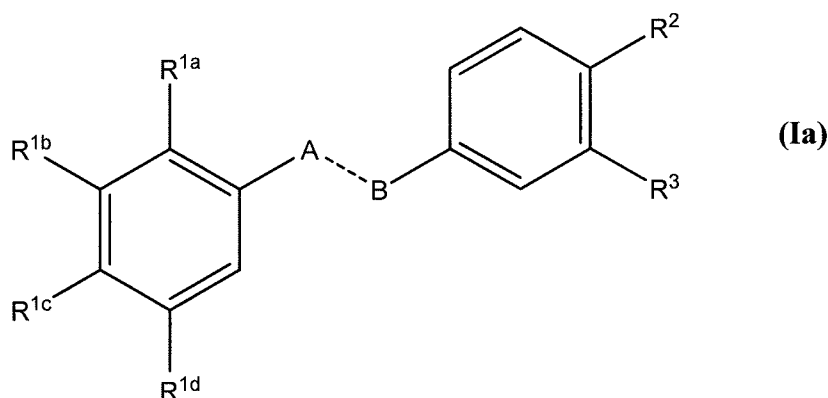
and A---B is selected from $CH=CH$, CH_2-CH_2 , $CH=CHX$, or CH_2-CH_2X ,

where $X=(CH_2)_pCH_2$, and p is an integer selected from the group consisting of 0, 1, 2 or 3; provided that:

(i) when R^3 is H and R^2 is OH or $OCH_2CH=C(CH_3)_2$, then R^{1b} and R^{1d} are independently not OH or $OCH_2CH=C(CH_3)_2$;

(ii) when R^3 is H, one of R^{1a-1d} is H and at least one of R^{1a-1d} is $CH_2CH=C(CH_3)_2$, then A---B is not $CH=CH$.

In a sixteenth aspect, there is provided a compound of formula (Ia)



or a pharmaceutically acceptable salt or solvate thereof, wherein:

R^{1a} , R^{1b} , R^{1c} and R^{1d} are each independently H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$, wherein at least one of R^{1a-1d} is $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^2 and R^3 are each independently selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

and A---B is selected from $CH=CH$, CH_2-CH_2 , $CH=CHX$, or $-CH_2-CH_2X$, where $X=(CH_2)_pCH_2$ and p is an integer selected from the group consisting of 0, 1, 2 or 3.

In a seventeenth aspect, there is provided a pharmaceutical composition comprising a compound of formula (Ia) according to the fifteenth or sixteenth aspects, or a pharmaceutically acceptable salt or solvate thereof, and a

pharmaceutically acceptable excipient.

According to an eighteenth aspect, there is provided a method for treating cancer, immunosuppression, inflammation, bacterial infection, fungal infection or skin aging comprising administering a therapeutically effective amount of a compound of formula (Ia) according to the fifteenth or sixteenth aspects, or a pharmaceutical composition including said compounds to a patient in need thereof.

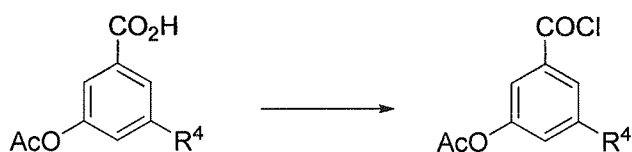
In a nineteenth aspect, there is provided a use of a compound of formula (Ia) according to the fifteenth or sixteenth aspects, or a pharmaceutical composition thereof in the preparation of a medicament for the treatment of cancer, immunosuppression, inflammation, bacterial infection, fungal infection or skin aging.

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According to the twentieth aspect, there is provided a method of preparing compounds of formula (Ib) which comprises the following steps:

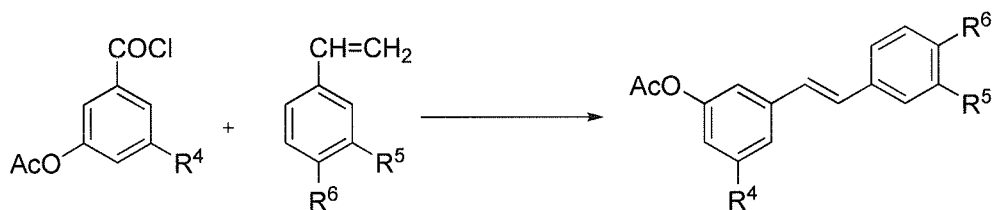
- (i) treating the carboxylic acid with a suitable agent to provide the acid chloride as follows;

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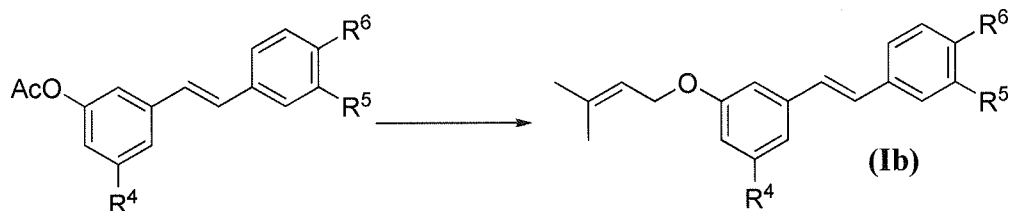


- (ii) condensation of the corresponding acid chloride with an aryl alkene as follows;

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- (iii) deprotection of the acetate group and alkylation as follows;



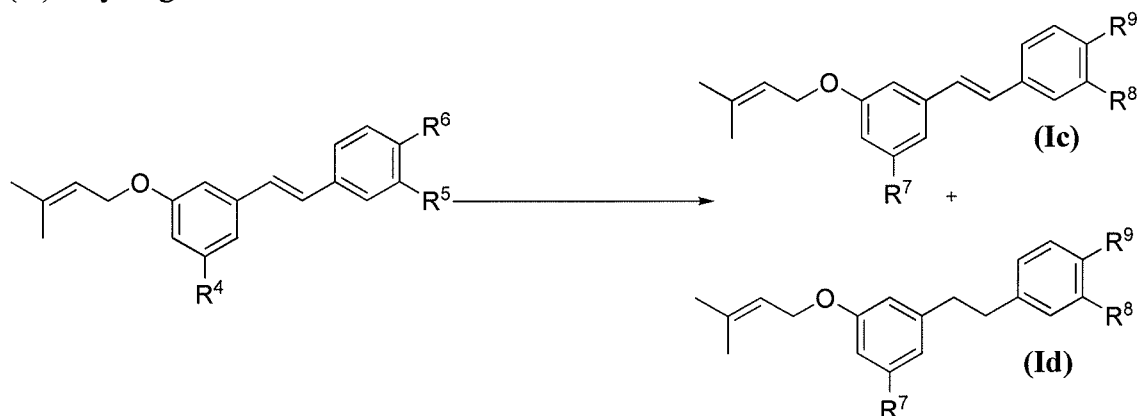
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wherein, R^4 , R^5 and R^6 are each independently selected from the group OMe, OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu, OBn.

In one embodiment, the method comprises the additional step as follows:

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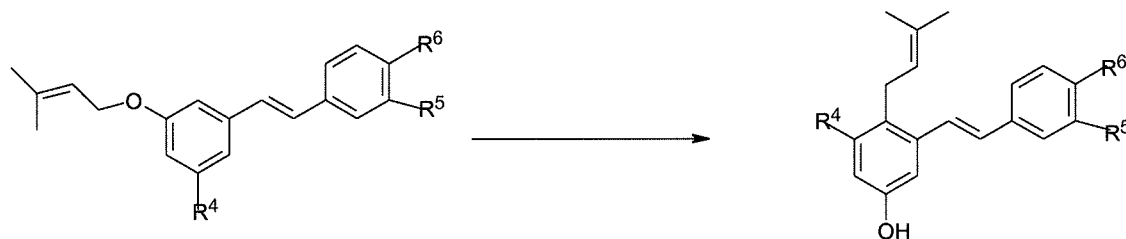
(iv) a hydrogenation reaction as follows:



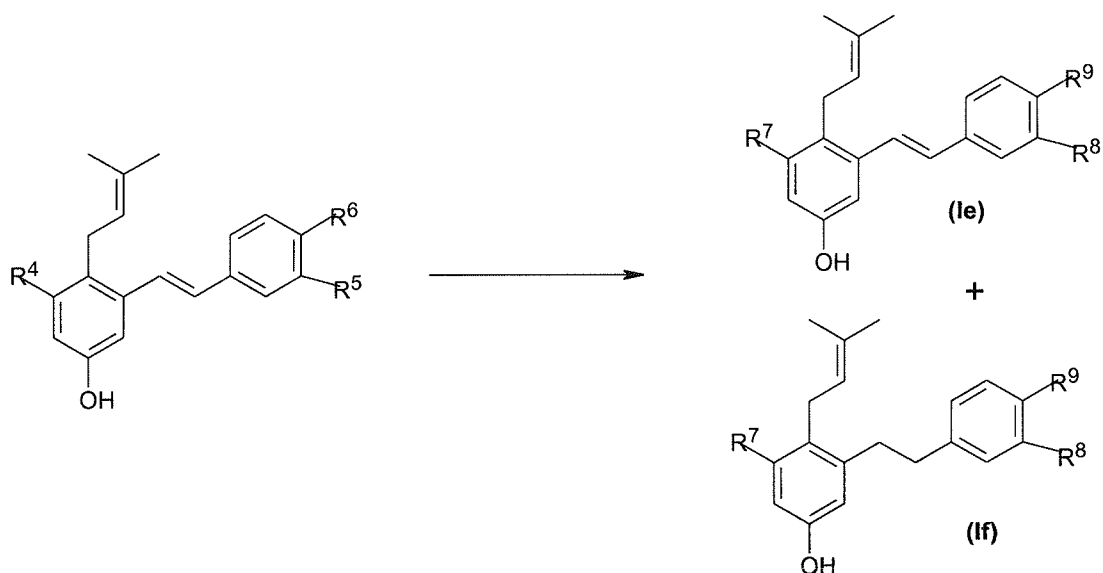
- wherein, R^4 , R^5 and R^6 are as previously defined, provided that at least one of R^4 , R^5 or R^6 is OBn;
 R^7 , R^8 and R^9 are each independently selected from the group OH, OMe, OEt, OPr, OⁱPr, O^tBu, OⁱBu, O^tBu.

In another embodiment the method comprises two additional steps as follows:

(v) rearrangement of the prenyl group as follows:



(vi) and a hydrogenation reaction as follows:

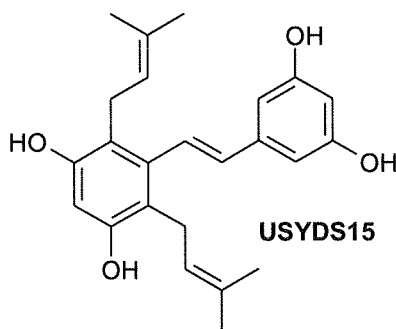


wherein, R^4 , R^5 and R^6 are as previously defined, provided that at least one of R^4 , R^5 or R^6 is OBn;

R^7 , R^8 and R^9 are each independently selected from the group OH, OMe, OEt, OPr,

5 OⁱPr, OBu, OⁱBu, O^tBu.

In a twenty first aspect, there is provided a compound according to USYDS15 as identified below



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There is also provided a pharmaceutical composition comprising the compound USYDS15 according to the twenty first aspect, or a pharmaceutically acceptable salt or solvate thereof, and a pharmaceutically acceptable excipient.

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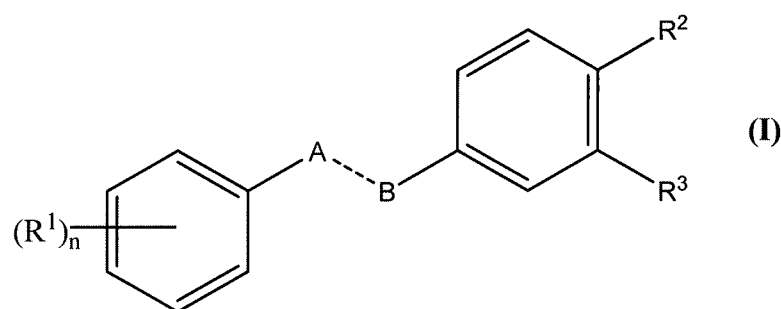
In a twenty third aspect, there is provided use of the compound according to the twenty first aspect or the composition of the twenty second aspect, in the preparation of a medicament for the treatment of cancer, immunosuppression, inflammation, fungal or bacterial infection, or for the treatment of skin aging.

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Specific embodiments of the disclosure are defined below in the following items:

1. A method for treating cancer comprising administering a therapeutically effective amount of a compound of formula (I),

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wherein:

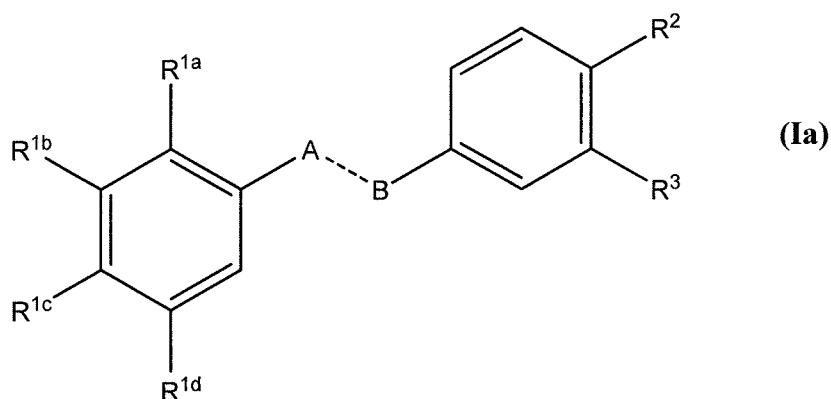
- R^1 is independently OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$, wherein at least one of R^1 is OH and at least one of R^1 is $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$ or $OCH=CHC(CH_3)=CH_2$;
- R^2 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
- R^3 is selected from H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
- R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;
- n is an integer selected from the group consisting of 2, 3 or 4;
- and A---B is selected from CH=CH, CH₂-CH₂, CH=CHX, or CH₂-CH₂X, where X=(CH₂)_pCH₂, and p is an integer selected from the group consisting of 0, 1, 2 or 3;

30

provided that:

- (i) when R^2 is OH, R^3 is H or OH, A---B is CH=CH, n is 3 and two of the R^1 groups are OH located in the meta positions, and the third R^1 group is located in the para position, then the third R^1 group is not CH=CHCH(CH₃)₂ or CH₂CH=C(CH₃)₂;
- (ii) when R^2 is OH and R^3 is H, A---B is CH=CH, n is 4 and two of the R^1 groups are CH₂CH=C(CH₃)₂, at least one of the CH₂CH=C(CH₃)₂ groups is not located in an ortho position;
- (iii) when R^2 is OH and R^3 is H, A---B is CH=CH, n is 3 and one of the R^1 groups is CH₂CH=C(CH₃)₂, the CH₂CH=C(CH₃)₂ group is not located in an ortho position;
- (iv) when R^2 is OH and R^3 is H, A---B is CH₂-CH₂-CH₂ and n is 3 such that two R^1 groups are OH in the ortho and para position, and one R^1 group is CH₂CH=C(CH₃)₂, the CH₂CH=C(CH₃)₂ group is not located in a meta position; and
- (v) when R^2 is OH and R^3 is H, A---B is CH₂=CH₂ and n is 3 such that two R^1 groups are OH in the meta position and one R^1 group is CH₂CH=C(CH₃)₂, the CH₂CH=C(CH₃)₂ group is not located in an ortho position; and
- (vi) when R^2 is OH and R^3 is H, A---B is CH₂=CH₂ and n is 4 such that two R^1 groups are OH in the meta position and two R^1 groups are CH₂CH=C(CH₃)₂, the CH₂CH=C(CH₃)₂ groups are not both located in an ortho position;
- (vii) when R^2 is OH and R^3 is OH, A---B is CH₂-CH₂ and n is 4 and two of the R^1 groups are CH₂=CHCH(CH₃)₂ and/or CH₂CH=C(CH₃)₂, the CH₂=CHCH(CH₃)₂ and/or CH₂CH=C(CH₃)₂ groups are not both located in an ortho position or an ortho and para position;
- (viii) when R^2 is OH, A---B is CH=CH and n is 2 and one of the R^1 group is CH₂CH=C(CH₃)₂ and the other is OH, then the R^1 groups are not both located in a meta position,
- or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds, to a patient in need thereof.

2. A method for treating cancer, immunosuppression or a bacterial infection, comprising administering a therapeutically effective amount of a compound of formula (Ia),



or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds,

5 wherein:

R^{1a} is selected from the group consisting of OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,

10 R^{1b} is selected from the group consisting of H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,

R^{1c} is selected from the group consisting of H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,

15 R^{1d} is selected from the group consisting of H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,

wherein at least one of R^{1a-1d} is OH and at least one of R^{1a-1d} is

20 $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$ or $OCH=CHC(CH_3)=CH_2$;

R^2 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

25 R^3 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

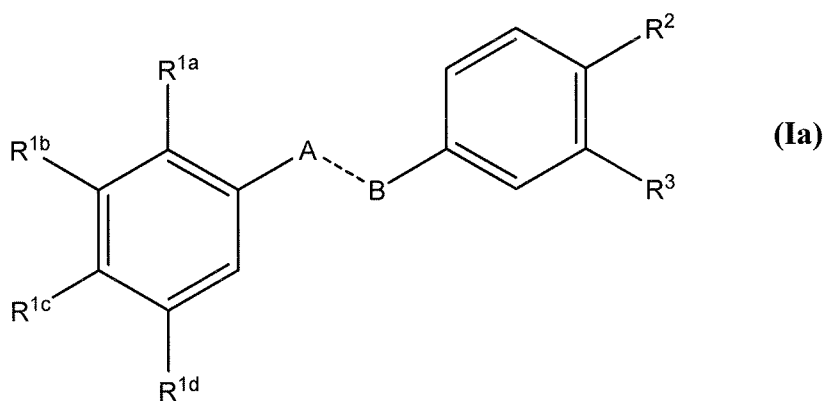
and A---B is selected from CH=CH, CH₂-CH₂, CH=CHX, or CH₂-CH₂X, where X=(CH₂)_pCH₂, and p is an integer selected from the group consisting of 0, 1, 2 or 3.

3. A method for treating cancer according to item 1 or 2

R^3 is selected from OH, OR⁴, CH₂CH=C(CH₃)₂, OCH₂CH=C(CH₃)₂, CH=CHCH(CH₃)₂, CH=CHC(CH₃)=CH₂, OCH=CHCH(CH₃)₂, or OCH=CHC(CH₃)=CH₂.

4. The method of any one of items 1-3 wherein A---B is selected from CH=CH or CH₂-CH₂.

5. A method for treating cancer, immunosuppression, inflammation or a bacterial infection, comprising administering a therapeutically effective amount of a compound of formula (Ia),



wherein:

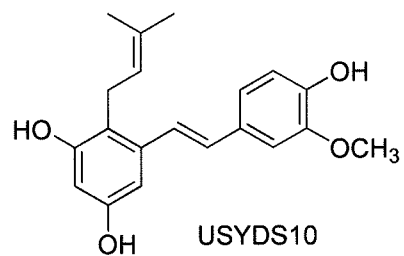
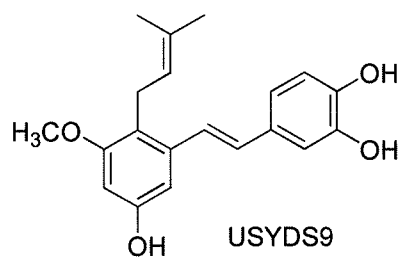
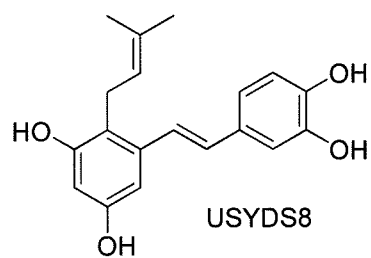
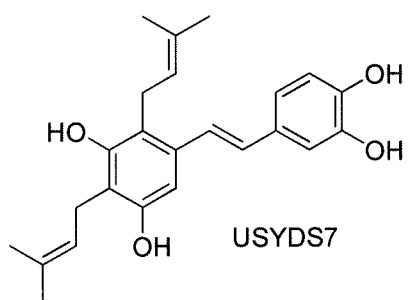
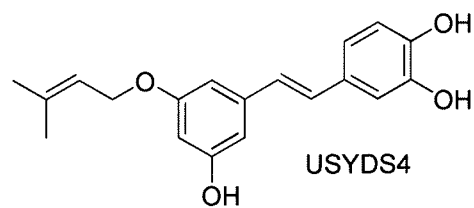
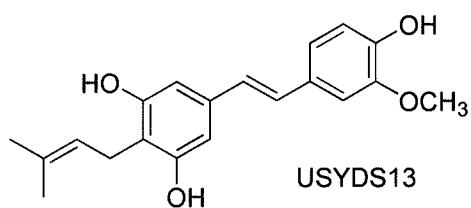
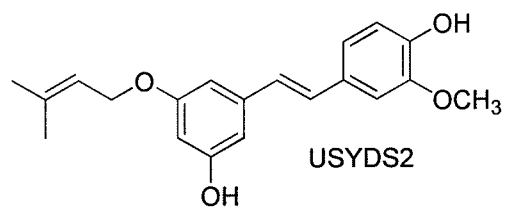
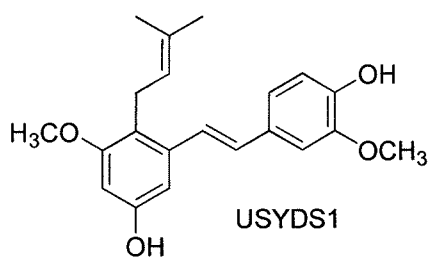
R^{1a} is CH₂CH=C(CH₃)₂ and R^{1c} is H or CH₂CH=C(CH₃)₂; R^{1b} is selected from OH, OCH₃ or OCH₂CH=C(CH₃)₂; R^{1d} is OH; wherein at least one of R^{1a} or R^{1c} is CH₂CH=C(CH₃)₂ and/or R^{1b} is OCH₂CH=C(CH₃)₂; R^2 is selected from OH or OCH₃; R^3 is selected from OH or OCH₃;

and A---B is CH=CH;

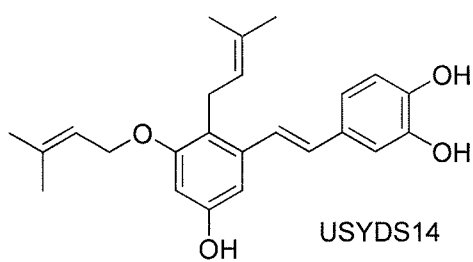
or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds, to a patient in need thereof.

6. A method according to item 1, wherein the compound is selected from the group consisting of:

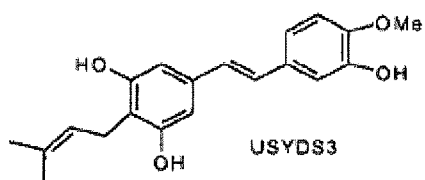
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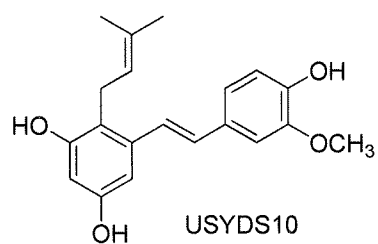
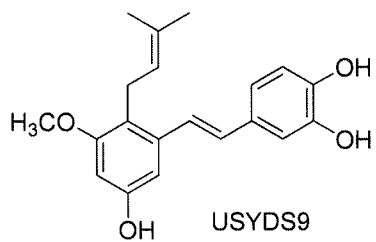
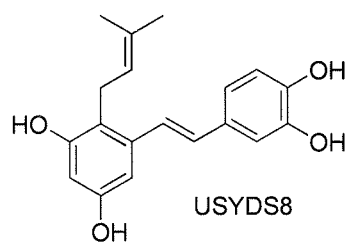
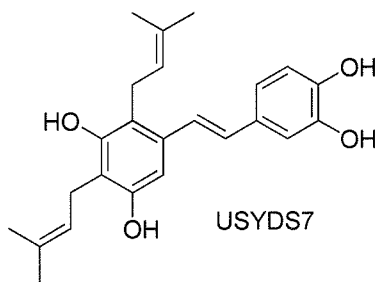
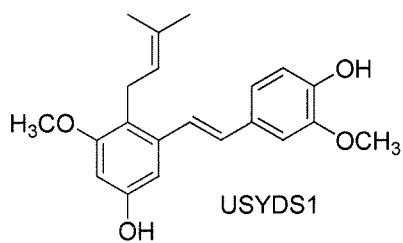


and

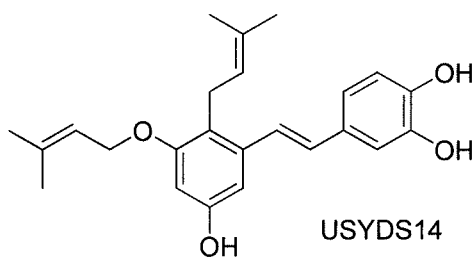


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7. A method according to item 2, wherein the compound is selected from the group consisting of:

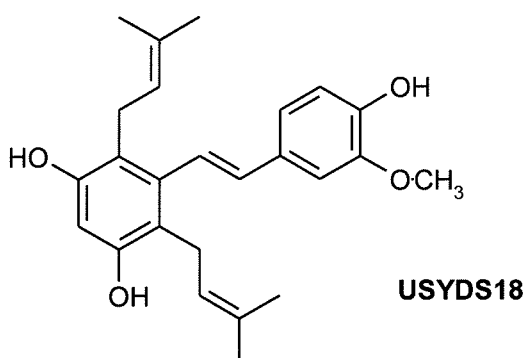


10



8. A method for treating cancer, immunosuppression, inflammation or a bacterial infection, wherein the compound is:

5



or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds, to a patient in need thereof.

10

9. A method according to any one of the preceding items for the treatment of cancer, wherein the cancer is leukemia, non-small cell lung cancer, colon cancer, CNS cancer, melanoma, ovarian cancer, renal cancer, prostate cancer or breast cancer.

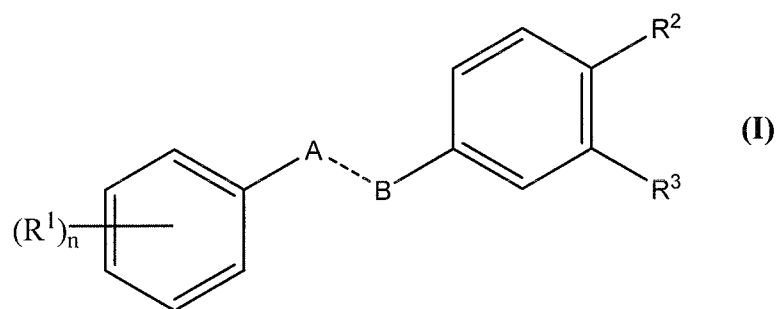
15

10. A method according to item 9 wherein the cancer is leukemia.

11. A method according to item 9 wherein the cancer is melanoma.

12. Use of a compound of formula (I),

20



or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds,

5 wherein:

R^1 is independently OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$, wherein at least one of R^1 is OH and at least one of R^1 is $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$,

10 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$ or $OCH=CHC(CH_3)=CH_2$;

R^2 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

15 R^3 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

n is an integer selected from the group consisting of 2, 3 or 4;

20 and A----B is selected from $CH=CH$, $CH_2CH_2CH_2$, $CH=CHX$, or CH_2-CH_2X , where $X=(CH_2)_pCH_2$, and p is an integer selected from the group consisting of 1 or 2;

provided that:

25

(i) when R^2 is OH, R^3 is OH, A----B is $CH=CH$, n is 3 and two of the R^1 groups are OH located in the meta positions, then the third R^1 group selected from the group consisting of $OCH_2CH=C(CH_3)_2$, $OCH=CHCH(CH_3)_2$, $OCH=CHC(CH_3)=CH_2$, $CH=CHC(CH_3)=CH_2$, $CH=CHCH(CH_3)_2$ and $CH_2CH=C(CH_3)_2$ is not located in the para position;

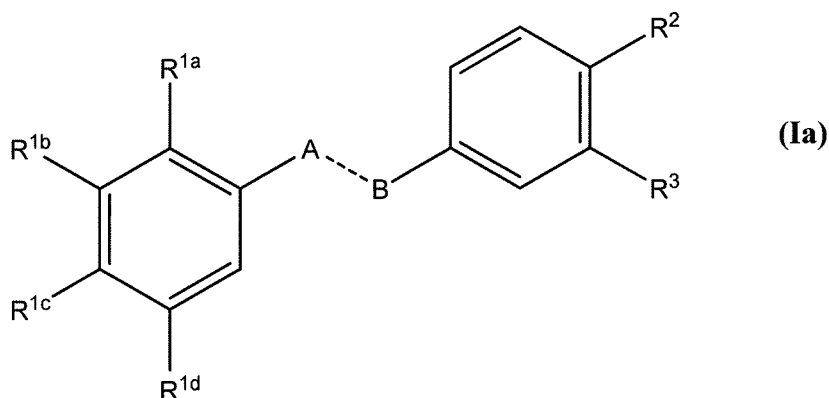
30

(ii) when R^2 is OH, A---B is CH=CH and n is 2 and one of the R^1 group is $CH_2CH=C(CH_3)_2$ and the other is OH, then the R^1 groups are not both located in a meta position, and

iii) when $R^2 = OMe$, $n=3$, A---B is CH=CH and one R^1 group is $CH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$ or $CH=CHC(CH_3)=CH_2$ in the ortho position and the other two R^1 groups are OH and OMe in the meta positions, then R^3 cannot be OMe;

in the preparation of a medicament for treating cancer.

Use of a compound of formula (Ia),



or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compounds,

wherein:

R^{1a} is selected from the group consisting of, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,

R^{1b} is selected from the group consisting of H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$,

$CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,

R^{1c} is selected from the group consisting of H, OH, OR^4 ,

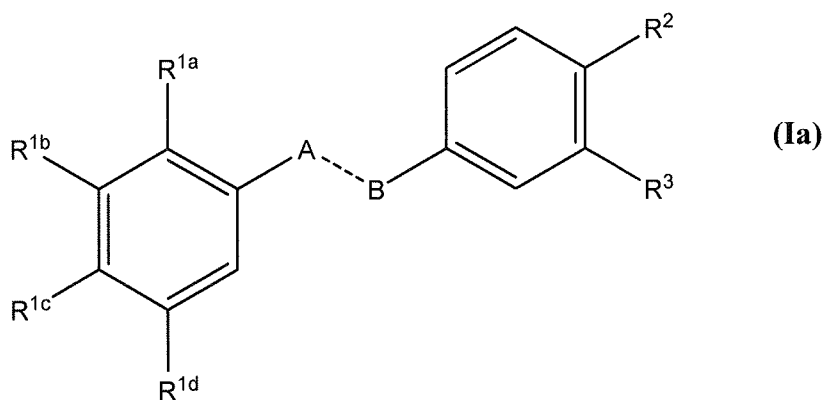
$CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$,

$CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,

- R^{1d} is selected from the group consisting of H, OH, OR^4 ,
 $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$,
 wherein at least one of R^{1a-1d} is OH and at least one of R^{1a-1d} is
 5 $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$ or $OCH=CHC(CH_3)=CH_2$;
 R^2 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or
 $OCH=CHC(CH_3)=CH_2$;
 10 R^3 is selected from OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or
 $OCH=CHC(CH_3)=CH_2$;
 R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or
 benzyl;
 15 and A---B is selected from $CH=CH$, $CH_2-CH_2-CH_2$, $CH=CHX$, or CH_2-CH_2X ,
 where $X=(CH_2)_pCH_2$, and p is an integer selected from the group consisting of 1
 or 2.

20 in the preparation of a medicament for treating cancer, immunosuppression or a
 bacterial infection.

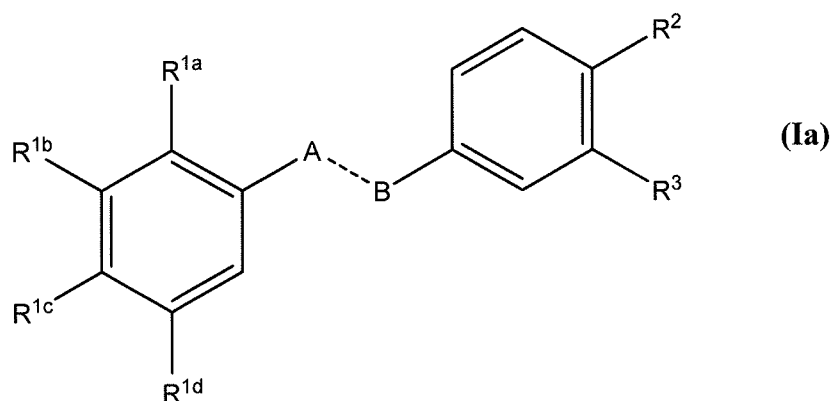
14. A compound of formula (Ia)



- 25 or a pharmaceutically acceptable salt or solvate thereof, wherein:
 R^{1a} is selected from, $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;

- R^{1b} is selected from, H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or
 $OCH=CHC(CH_3)=CH_2$;
 R^{1c} is selected from H, OH, OR^{4a} , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 5 $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or
 $OCH=CHC(CH_3)=CH_2$;
 R^{1d} is selected from H, OH, $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHCH(CH_3)_2$, $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or
 $OCH=CHC(CH_3)=CH_2$;
 10 wherein at least one of R^{1b-1d} is OH and at least one of R^{1a-1d} is
 $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHCH(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
 R^2 is selected from OH, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$,
 $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
 15 R^3 is selected from OH, OR^4 , $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$,
 $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
 R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or
 benzyl;
 R^{4a} is selected from, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;
 20 and A---B is selected from $CH=CH$, $CH_2CH_2CH_2$, $CH=CHX$, or $-CH_2-CH_2X$,
 where $X=(CH_2)_pCH_2$ and *p* is an integer selected from the group consisting of 1
 or 2.

15. A compound of formula (Ia)
 25

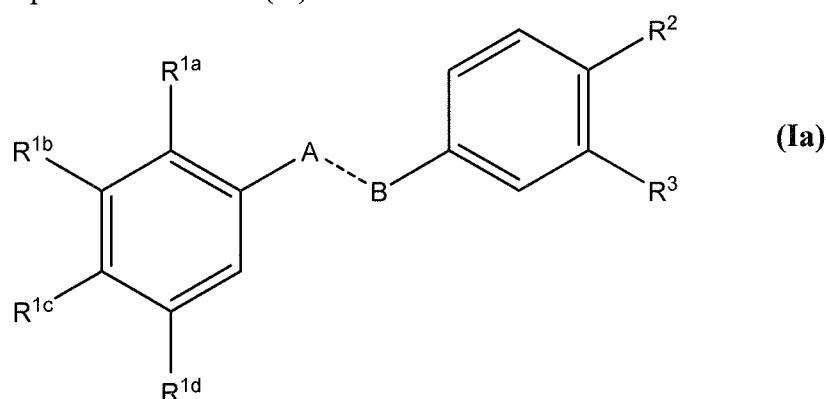


or a pharmaceutically acceptable salt or solvate thereof, wherein:

- R^{1a} is selected from, $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
 R^{1b} is selected from, H, OH, OR^4 , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
5 R^{1c} is selected from H, OH, OR^{4a} , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
 R^{1d} is selected from H, OH, OR^{4a} , $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
wherein at least one of R^{1b-1d} is OH and at least one of R^{1a-1d} is
10 $CH_2CH=C(CH_3)_2$, $OCH_2CH=C(CH_3)_2$, $CH=CHC(CH_3)=CH_2$,
 $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
 R^2 and R^3 are each independently selected from OH, OR^4 , $OCH_2CH=C(CH_3)_2$,
 $CH=CHC(CH_3)=CH_2$, $OCH=CHCH(CH_3)_2$, or $OCH=CHC(CH_3)=CH_2$;
 R^4 is selected from, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or
15 benzyl;
 R^{4a} is selected from, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;
and A---B is selected from $CH=CH$, $CH_2CH_2CH_2$, $CH=CHX$, or $-CH_2-CH_2X$,
where $X=(CH_2)_pCH_2$ and p is an integer selected from the group consisting of 1
or 2.

20

16. A compound of formula (Ia)



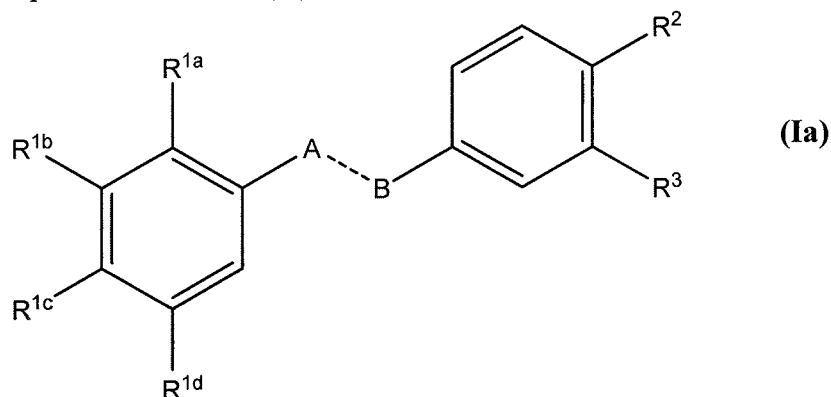
or a pharmaceutically acceptable salt or solvate thereof,

wherein:

- 25 R^{1a} is $CH_2CH=C(CH_3)_2$ or $CH=CHCH(CH_3)_2$
 R^{1c} is selected from H or $CH_2CH=C(CH_3)_2$ or $CH=CHCH(CH_3)_2$; R^{1b} is selected
from OH, OCH_3 or $OCH_2CH=C(CH_3)_2$; and
 R^{1d} is OH;

wherein at least one of R^{1a} or R^{1c} is $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$ and/or R^{1b} is $\text{OCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$; R^2 is selected from OH or OCH_3 ; R^3 is OCH_3 ; and A----B is $\text{CH}=\text{CH}$.

- 5 17. A compound of formula (Ia)



or a pharmaceutically acceptable salt or solvate thereof, wherein:

- 10 R^{1a} is $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$ or $\text{CH}=\text{CHCH}(\text{CH}_3)_2$; R^{1b} is selected from OH, OCH_3 or $\text{OCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$; R^{1c} is selected from H or $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$ or $\text{CH}=\text{CHCH}(\text{CH}_3)_2$; R^{1d} is OH; wherein at least one of R^{1a} or R^{1c} is $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$ and/or R^{1b} is $\text{OCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$; R^2 is selected from OH or OCH_3 ; R^3 is selected from OH or OCH_3 ; and A----B is $\text{CH}=\text{CH}$.

- 15 18. A compound according to item 14 or 15 wherein one of R^{1a-1d} is H.

19. A compound according to item 14 or 15 wherein none of R^{1a-1d} are H.

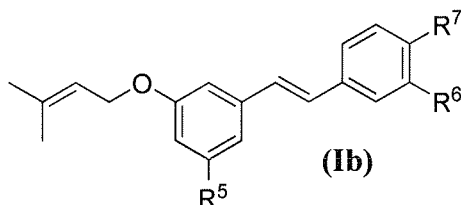
- 20 21. A compound according to item 14 or 15 wherein at least one of R^{1a-1d} is $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$.

21. A compound according to item 14 or 15 wherein at least one of R^{1a-1d} is $\text{OCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$.

- 25 22. A compound according to item 14 or 15 wherein at least two of R^{1a-1d} are OH.

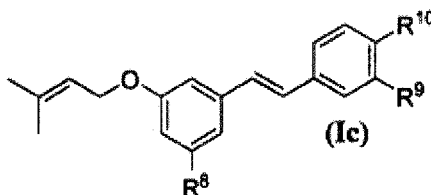
23. A compound according to item 14 or 15 wherein at least one of R^{1a-1d} is OR^4 and R^4 is methyl.

24. A compound according to item 14 or 15 wherein at least one of R^2 or R^3 is OH.
25. A compound according to item 14 or 15 wherein R^3 is OR^4 and R^4 is methyl.
- 5 26. A compound according to item 14 or 15 wherein both R^2 and R^3 are OH.
27. A compound according to item 14 or 15 wherein A---B is $CH=CH$ or $CH=CHX$, where $X=(CH_2)_pCH_2$, and p is an integer selected from the group consisting
- 10 of 1 or 2.
28. A compound with the formula of (Ib):



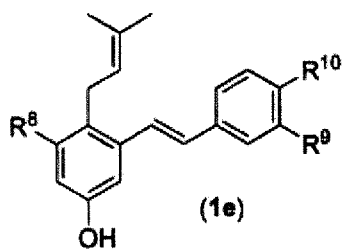
- wherein, R^5 is selected from the group OEt, OPr, O^iPr , OBu, O^iBu , O^tBu , OBn; and
- 15 R^6 and R^7 are each independently selected from the group OMe, OEt, OPr, O^iPr , OBu, O^iBu , O^tBu , OBn.

29. A compound with the formula of (Ic):



- 20 wherein, R^8 is selected from the group OH, OEt, OPr, O^iPr , OBu, O^iBu , O^tBu ; and R^9 and R^{10} are each independently selected from the group OH, OMe, OEt, OPr, O^iPr , OBu, O^iBu , O^tBu .

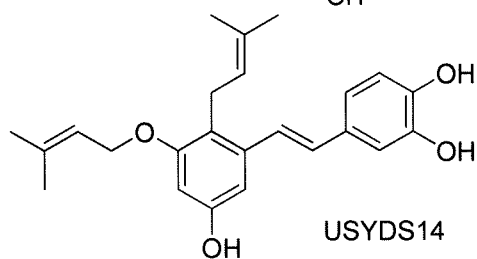
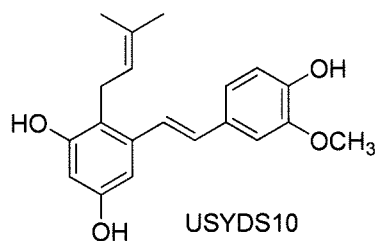
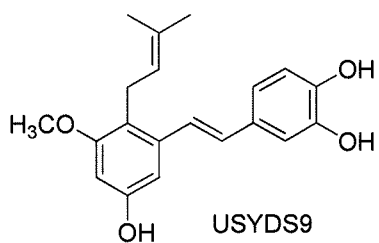
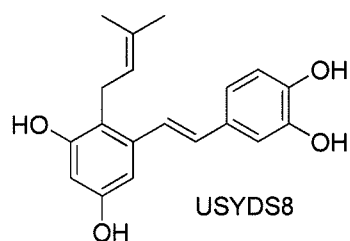
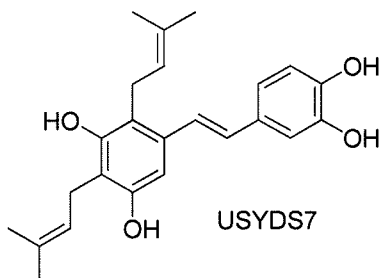
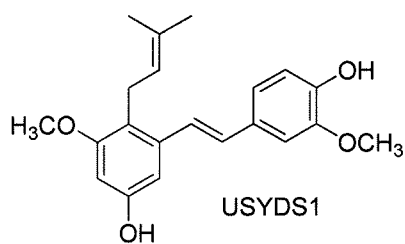
- 25 30. A compound with the formula of (Ie):



wherein, R^8 , R^9 and R^{10} are each independently selected from the group OH, OMe, OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu.

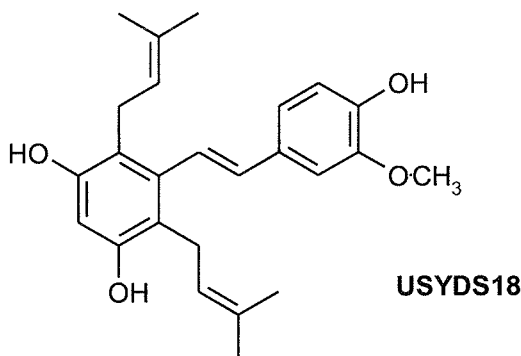
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31 A compound according to item 14 or 15, selected from the group consisting of:



or pharmaceutically acceptable salt or solvate thereof.

32. A compound according to structure USYDS18:



5

33. A compound according to any one of items 14 to 32 wherein the compound is chemically synthesised.

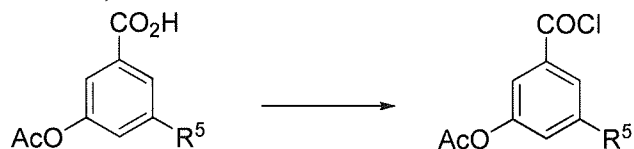
34. A compound according to any one of items 14 to 32 isolated from propolis,
10 wherein the propolis originates from plants of the *Lepidosperma* genus.

35. A compound according to anyone of items 14 to 32 isolated from the resin, gum or exudate of the *Lepidosperma* genus.

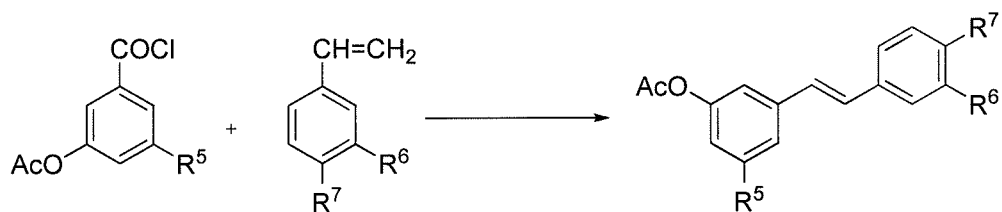
15 36. A pharmaceutical composition comprising a compound according to any one of items 14 to 32, or a pharmaceutically acceptable salt or solvate thereof, and a pharmaceutically acceptable excipient.

37. A method of preparing the compounds according to item 28 which comprises:

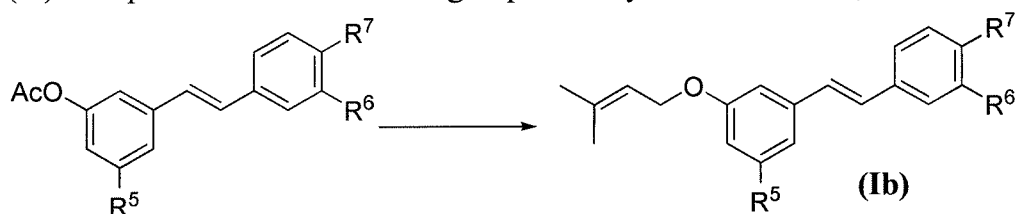
20 (i) treating the carboxylic acid with a suitable agent to provide the acid chloride as follows;



(ii) condensation of the corresponding acid chloride with an aryl alkene as follows;



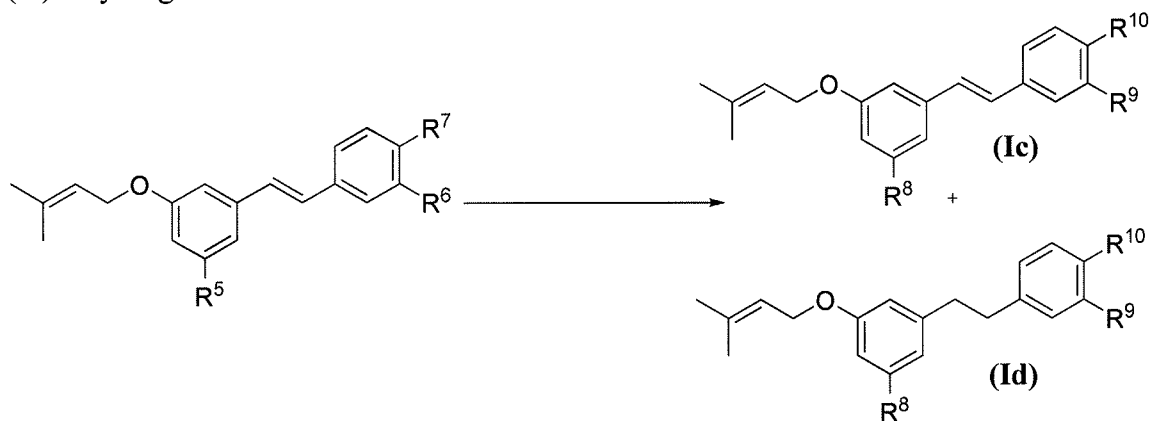
(iii) deprotection of the acetate group and alkylation as follows;



- wherein, R^5 is selected from the group OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu, OBn; and
 5 R^6 and R^7
 are each independently selected from the group OMe, OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu, OBn.

38. A method according to item 37 for preparing compounds of formula (Ic)
 10 according to item 29, comprising the additional step:

(iv) a hydrogenation reaction as follows:

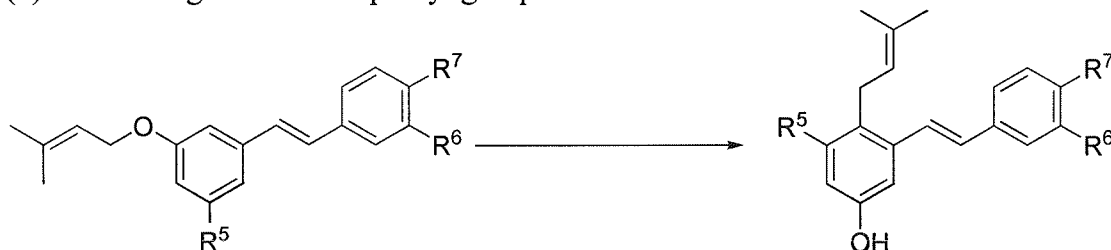


- 15 wherein, R^5 , R^6 and R^7 are as defined in claim 41, provided that at least one of R^5 , R^6 or R^7 is OBn;
 wherein, R^8 is selected from the group OH, OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu; and

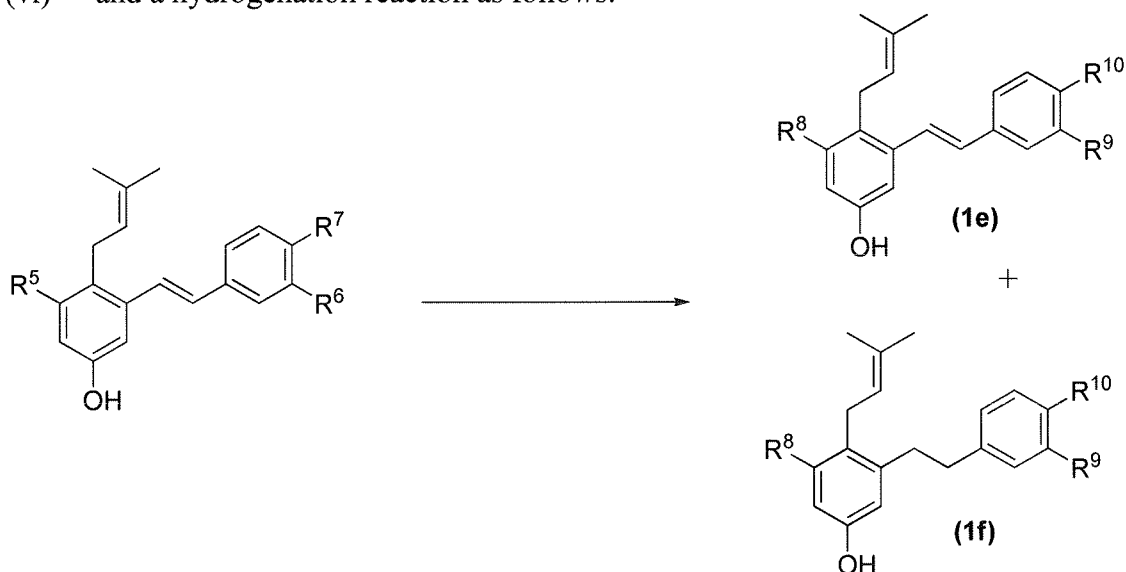
R^9 and R^{10} are each independently selected from the group OH, OMe, OEt, OPr, O^i Pr, OBu, O^i Bu, O^t Bu.

39. A method according to item 37 for preparing compounds of formula (1e)
5 according to item 30, comprising the additional steps:

(v) rearrangement of the prenyl group as follows:



(vi) and a hydrogenation reaction as follows:



10

wherein, R^5 , R^6 and R^7 are as defined in item 41, provided that at least one of R^5 , R^6 or R^7 is OBn;

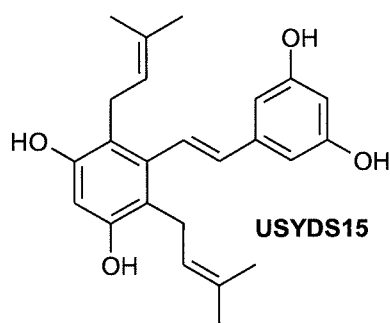
R^8 , R^9 and R^{10} are each independently selected from the group OH, OMe, OEt, OPr, O^i Pr, OBu, O^i Bu, O^t Bu.

15

40. A method according to item 39 wherein the rearrangement in step (v) is carried out in the presence of magnesium silicate particles, silica or alumina particles.

41. A method according to item 43 or 40 wherein the rearrangement in step (v) is
20 carried out in the presence of microwave radiation or light.

42. A compound according to structure USYDS15:



- 5 43. Use of the compound according to item 42 in the preparation of a medicament for the treatment of cancer, immunosuppression, inflammation, or a bacterial infection.

Description of the preferred embodiments of the Invention

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

While it is possible that, for use in therapy a therapeutically effective amount of the compounds as defined herein, or a pharmaceutically acceptable salt or solvate thereof, may be administered as the raw chemical; in one aspect of the present invention the active ingredient is presented as a pharmaceutical composition. Thus, in a further embodiment the invention provides a pharmaceutical composition comprising a compound of formula (I) or (Ia) according to the first, second, fifteenth and sixteenth aspects, or a pharmaceutically acceptable salt or solvate thereof, in admixture with one or more pharmaceutically acceptable carriers, diluents, or excipients. The carrier(s), diluent(s) or excipient(s) must be acceptable in the sense of being compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

When applicable, the compounds of the present invention, including the compounds of formula (I) or (Ia) may be in the form of and/or may be administered as a pharmaceutically acceptable salt.

As used herein the term "pharmaceutically acceptable salt" refers to salts which are toxicologically safe for systemic administration. The pharmaceutically acceptable salts may be selected from alkali or alkaline earth metal salts, including, sodium, lithium, potassium, calcium, magnesium and the like, as well as non-toxic ammonium, quaternary ammonium, and amine cations, including, but not limited to ammonium, tetramethylammonium, tetraethylammonium, methylamine, dimethylamine, trimethylamine, triethylamine, ethylamine, triethanolamine and the like.

As used herein the term "pharmaceutically acceptable excipient" refers to a solid or liquid filler, diluent or encapsulating substance that may be safely used in systemic administration. Depending upon the particular route of administration, a variety of carriers, well known in the art may be used. These carriers or excipients may be
5 selected from a group including sugars, starches, cellulose and its derivatives, malt, gelatine, talc, calcium sulfate, vegetable oils, synthetic oils, polyols, alginic acid, phosphate buffered solutions, emulsifiers, isotonic saline, and pyrogen-free water.

As used herein, the term "solvate" refers to a complex of variable stoichiometry formed
10 by a solute (in this invention, a compound of formula (I) or (Ia) or a salt or physiologically functional derivative thereof) and a solvent. Such solvents for the purpose of the invention may not interfere with the biological activity of the solute. Examples of suitable solvents include, but are not limited to, water, methanol, ethanol and acetic acid. In particular the solvent used is a pharmaceutically acceptable solvent.
15 Examples of suitable pharmaceutically acceptable solvents include, without limitation, water, ethanol, acetic acid, glycerol, liquid polyethylene glycols and mixtures thereof. A particular solvent is water.

Administration of compounds of the formula (I) or (Ia) may be in the form of a
20 "prodrug". A prodrug is an inactive form of a compound which is transformed *in vivo* to the active form. Suitable prodrugs include esters, phosphonate esters etc, of the active form of the compound.

It should be understood that in addition to the ingredients particularly mentioned above,
25 the formulations may include other agents conventional in the art having regard to the type of formulation in question.

The compounds of the present invention may be suitable for the treatment of diseases in a human or animal patient. In one embodiment, the patient is a mammal including a
30 human, horse, dog, cat, sheep, cow, or primate. In one embodiment the patient is a human. In a further embodiment, the patient is not a human.

As used herein, the term "effective amount" means that amount of a drug or pharmaceutical agent that will elicit the biological or medical response of a tissue,
35 system, animal or human that is being sought, for instance, by a researcher or clinician. Furthermore, the term "therapeutically effective amount" means any amount which, as

compared to a corresponding subject who has not received such amount, results in improved treatment, healing, prevention, or amelioration of a disease, disorder, or side effect, or a decrease in the rate of advancement of a disease or disorder. The term also includes within its scope amounts effective to enhance normal physiological function.

5

As used herein the term "treatment" refers to defending against or inhibiting a symptom, treating a symptom, delaying the appearance of a symptom, reducing the severity of the development of a symptom, and/or reducing the number or type of symptoms suffered by an individual, as compared to not administering a pharmaceutical composition comprising a compound of the invention. The term treatment encompasses the use in a palliative setting

10

Those skilled in the art will appreciate that in the preparation of the compounds of the invention it may be necessary and/or desirable to protect one or more sensitive groups in the molecule to prevent undesirable side reactions. Suitable protecting groups for use according to the present invention are well known to those skilled in the art and may be used in a conventional manner. See, for example, "Protective groups in organic synthesis" by T. W. Greene and P. G. M. Wuts (John Wiley & sons 1991) or "Protecting Groups" by PJ. Kocienski (Georg Thieme Verlag 1994). Examples of suitable amino protecting groups include acyl type protecting groups (e.g. formyl, trifluoroacetyl, acetyl), aromatic urethane type protecting groups (e.g. benzyloxycarbonyl (Cbz) and substituted Cbz), aliphatic urethane protecting groups (e.g. 9-fluorenylmethoxycarbonyl (Fmoc), t-butyloxycarbonyl (Boc), isopropyloxycarbonyl, cyclohexyloxycarbonyl) and alkyl type protecting groups (e.g. benzyl, trityl, chlorotriyl).

20

25

According to the first, second or eighteenth aspects, the cancers to be treated are leukemia, non-small cell lung cancer, colon cancer, CNS cancer, melanoma, ovarian cancer, renal cancer, prostate cancer or breast cancer. Most preferably, the cancer to be treated is leukemia or melanoma.

30

In a preferred embodiments of the first to ninth aspects, the compound according to formula (I) has the formula (Ia).

According to the tenth or nineteenth aspect, preferably the medicament is used to treat the following cancers; leukemia, non-small cell lung cancer, colon cancer, CNS cancer,

35

melanoma, ovarian cancer, renal cancer, prostate cancer or breast cancer. Most preferably, the medicament is used to treat leukemia or melanoma.

5 In preferred embodiments of the tenth to fourteenth aspects, the compound according to formula (I) has the formula (Ia).

10 The antitumor effect of the compounds of the present disclosure may be applied as a sole therapy or may involve, in addition, one or more other substances and/or treatments. Such conjoint treatment may be achieved by way of the simultaneous, sequential or separate administration of the individual components of the treatment. In the field of medical oncology it is normal practice to use a combination of different forms of treatment to treat each patient with cancer such as a combination of surgery, radiotherapy and/or chemotherapy. In particular, it is known that irradiation or treatment with antiangiogenic and/or vascular permeability reducing agents can
15 enhance the amount of hypoxic tissue within a tumour. Therefore the effectiveness of the compounds of the present invention may be improved by conjoint treatment with radiotherapy and/or with an antiangiogenic agent.

20 The individual components of such combinations can be administered separately at different times during the course of therapy or concurrently in divided or single combination forms. The present disclosure is therefore to be understood as embracing all such regimes of simultaneous or alternating treatment and the term "administering" is to be interpreted accordingly. It will be understood that the scope of combinations of the compounds of this invention with other anti-neoplastic agents includes in principle
25 any combination with any pharmaceutical composition useful for treating cancer.

When combined in the same formulation it will be appreciated that the two compounds must be stable and compatible with each other and the other components of the formulation and may be formulated for administration. When formulated separately
30 they may be provided in any convenient formulation, conveniently in such a manner as are known for such compounds in the art.

Pharmaceutical compositions of the present disclosure may be formulated for administration by any appropriate route, for example by the oral (including buccal or
35 sublingual), rectal, nasal, topical (including buccal, sublingual or transdermal), vaginal or parenteral (including subcutaneous, intramuscular, intravenous or intradermal) route.

Therefore, the pharmaceutical compositions of the invention may be formulated, for example, as tablets, capsules, powders, granules, lozenges, creams or liquid preparations, such as oral or sterile parenteral solutions or suspensions. Such pharmaceutical formulations may be prepared by any method known in the art of pharmacy, for example by bringing into association the active ingredient with the carrier(s) or excipient(s). Such pharmaceutical formulations may be prepared as enterically coated granules, tablets or capsules suitable for oral administration and delayed release formulations.

When a compound is used in combination with a second therapeutic agent active against the same disease, the dose of each compound may differ from that when the compound is used alone. Appropriate doses will be readily appreciated by those skilled in the art.

In one embodiment of the fifteenth aspect, there is provided a compound of formula (Ia) wherein R^{1a} - R^{1d} , R^2 , R^3 , R^4 and A---B are as hereinbefore defined provided that:

- (i) when R^3 is H, then R^{1b} and R^{1d} are independently not OH or $OCH_2CH=C(CH_3)_2$; and
- (ii) when R^3 is H, one of R^{1a-1d} is H and at least one of R^{1a-1d} is $CH_2CH=C(CH_3)_2$, then A---B is not $CH=CH$.

According to the fifteenth or sixteenth aspects, in preferred embodiments of the invention two of R^{1a-1d} are H. In other preferred embodiments one of R^{1a-1d} is H, and in other embodiments none of R^{1a-1d} are H.

In a preferred embodiment, at least one of R^{1a-1d} is $CH_2CH=C(CH_3)_2$, and in another preferred embodiment at least one of R^{1a-1d} is $OCH_2CH=C(CH_3)_2$.

In certain embodiments at least one of R^{1a-1d} is hydroxyl, and in certain other embodiments at least two of R^{1a-1d} are hydroxyl. In another embodiment at least one of R^{1a-1d} is OR^4 and R^4 is methyl, and in yet another embodiment R^4 is benzyl.

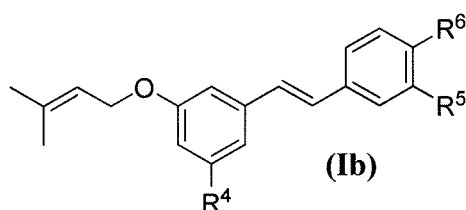
In preferred embodiments of the fifteenth or sixteenth aspects, at least one of R^2 or R^3 is hydroxyl. In another preferred embodiment both R^2 and R^3 are hydroxyl.

In another embodiment at least one of R^2 or R^3 is OR^4 and R^4 is methyl, and in yet another embodiment R^4 is benzyl.

- In preferred embodiments of the disclosure, the group A---B in formula (Ia) or is
 5 CH=CH or CH=CHX-, where $X=(CH_2)_pCH_2$, and p is an integer selected from the group consisting of 0, 1, 2 or 3.

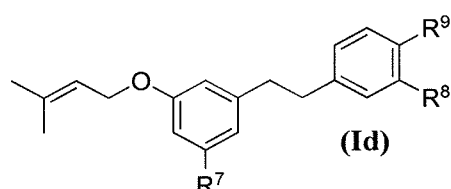
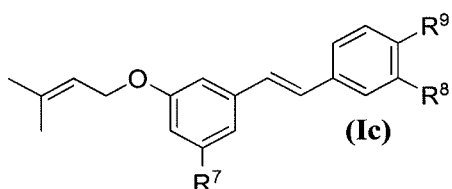
- In other embodiments of the disclosure the group A---B in formula (Ia) is CH_2-CH_2 , or CH_2-CH_2X , where $X=(CH_2)_pCH_2$, and p is independently an integer selected from the
 10 group consisting of 0, 1, 2 or 3.

In a preferred embodiment, the compound of formula (Ia) according to the fifteenth or sixteenth aspect has the formula (Ib):



- 15 Wherein, R^4 , R^5 and R^6 are each independently selected from the group OMe, OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu, OBn.

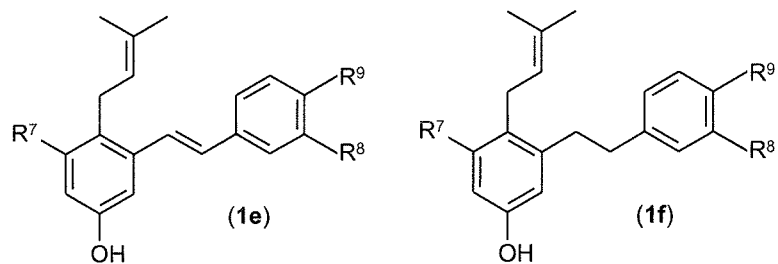
In another preferred embodiment the compound of formula (Ia) according to the fifteenth or sixteenth aspects has the formula (Ic) or (Id):



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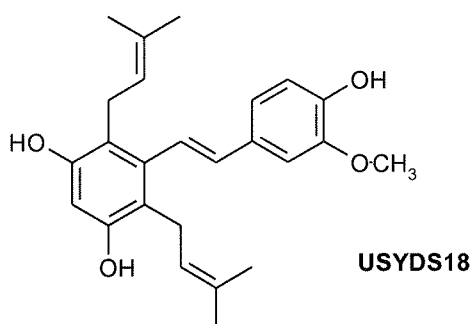
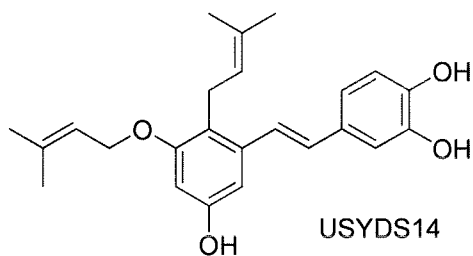
Wherein, R^7 , R^8 and R^9 are each independently selected from the group OH, OMe, -OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu.

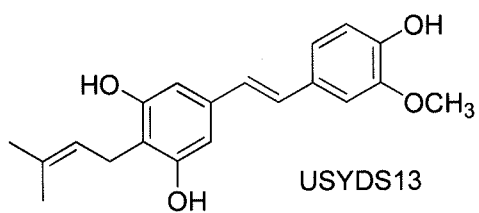
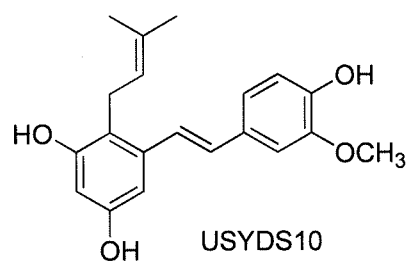
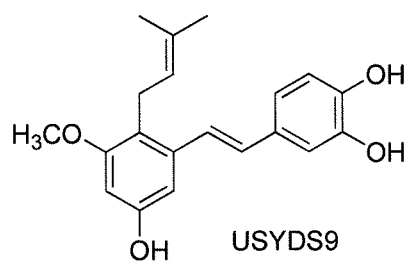
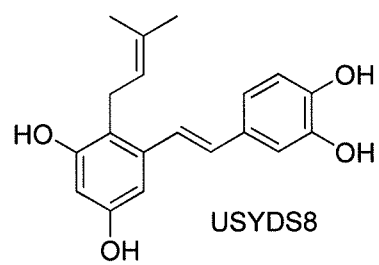
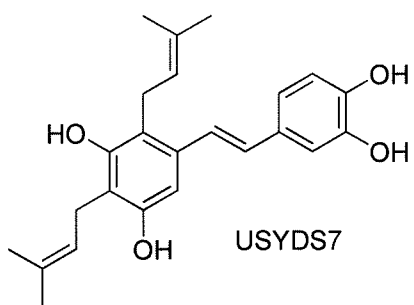
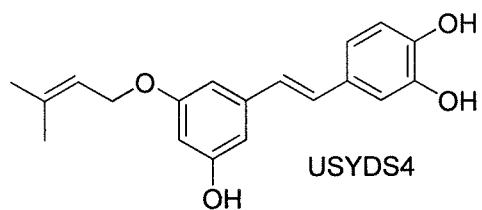
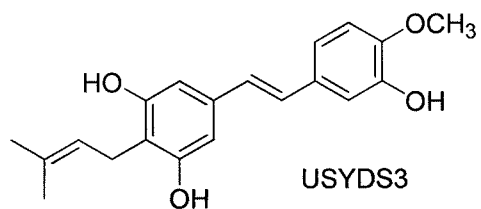
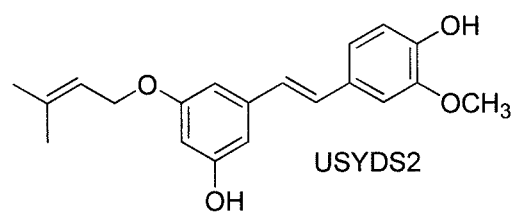
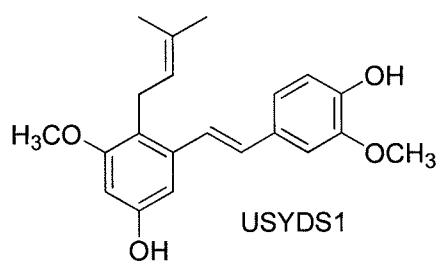
- 25 In yet another preferred embodiment, the compound of formula (Ia) according to the fifteenth or sixteenth aspects has the formula (Ie) or (If)



- 5 Wherein, R^7 , R^8 and R^9 are each independently selected from the group OH, OMe, OEt, OPr, OⁱPr, OBu, OⁱBu, O^tBu.

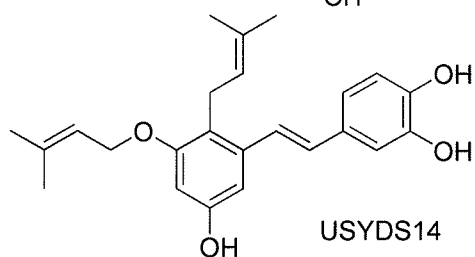
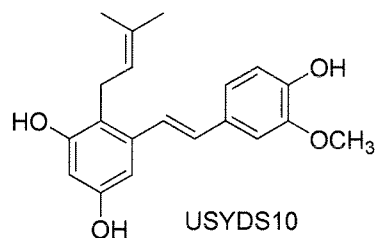
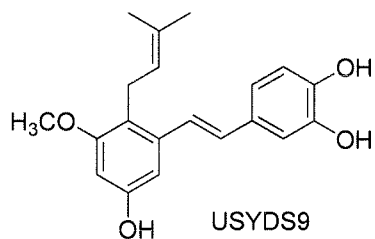
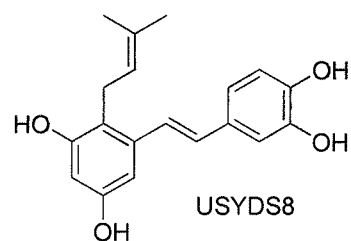
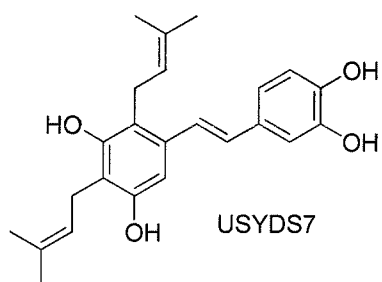
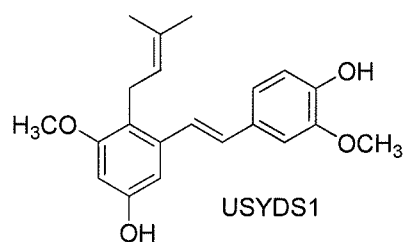
Preferably, the compound according to the fifteenth or sixteenth aspects, or pharmaceutically acceptable salt or solvate thereof is selected from the group consisting of:



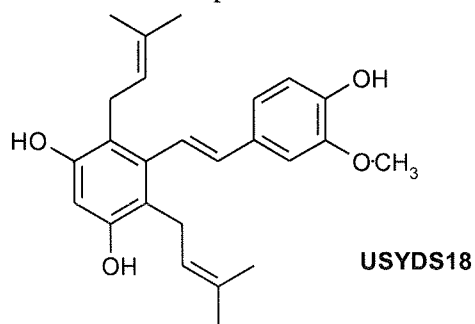


In one embodiment the compound according to the fifteenth or sixteenth aspects, or pharmaceutically acceptable salt or solvate thereof is selected from the group consisting of:

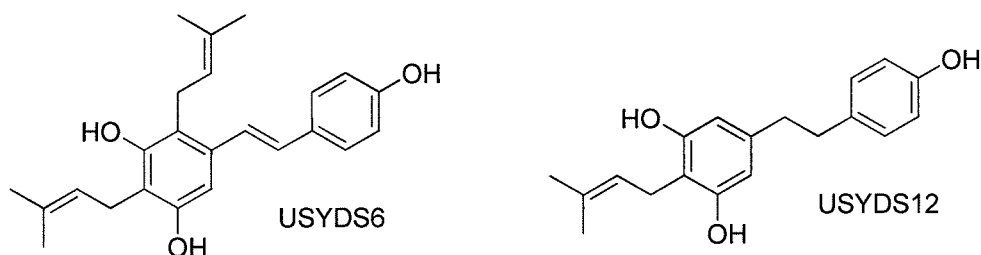
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In another preferred embodiment the compound is USYDS18.



In another preferred embodiment, the compound according to the fifteenth aspect, or pharmaceutically acceptable salt or solvate thereof is selected from the group consisting of:



In preliminary *in vitro* assays to determine the anticancer activity of prenylated polyhydroxystilbene derivatives, the inventors observed structure dependent inhibition of cancerous cell growth for all derivatives, USYDS1 to USYDS7 and USYDS13. Most of these compounds, exhibited potent inhibition of almost all leukemia cell lines (CCRF-CEM, HL-60(TB), K-562, MOLT-4, RPMI-8226, SR). In some cell lines, growth was inhibited at nano-molar concentrations. USYDS1 displayed the most potent activity followed by USYDS10, USYDS9, USYDS2 then USYDS14 in the inhibition of cancerous cell growth. Structure dependent inhibition of cancerous cell growth for derivatives USYDS10 and 14 have also been observed. Structure-activity study shows the C-prenylation at the 2 position with the methoxy group at 3 position exhibits the highest potency towards inhibition of cancer cells.

Most of the pTHOS in this study have structures built on the piceatannol structure, a known naturally occurring compound, which displays a wide spectrum of biological activity. It is now attracting much attention on its anticancer properties because of its ability to inhibit proliferation of a wide variety of tumor cells, including leukemia, lymphoma; cancers of the breast, prostate, colon and melanoma. Its anticancer effects are suggested to mediate through cell-cycle arrest; upregulation of Bid, Bax, Bik, Bok, Fas; P21WAF1 down-regulation of Bcl-xL; BCL-2, cIAP, activation of caspases, loss of mitochondrial potential, and release of cytochrome c. Piceatannol has also been shown to inhibit the activation of some transcription factors, including NF- κ B, which plays a central role in response to cellular stress caused by free radicals, ultraviolet irradiation, cytokines, or microbial antigens, JAK-1, a key transcription in the STAT pathway that controlling cellular activities in response to extracellular cytokines.

It has been observed that the pTHOS described in this study display a similar spectrum of biological activities to that exhibited by piceatannol. Furthermore, the pTHOS (ie. USYDS1, GI_{50} values: $0.02\ \mu\text{M} - 5\ \mu\text{M}$) showed approximately 250 fold more potent than piceatannol (IC_{50} values: $5\ \mu\text{M} - 100\ \mu\text{M}$) in inhibition of proliferation of almost all types of tumor cells. Therefore, the pTHOS present in this application will be an attractive lead for pharmaceutical research and development and as biological tools for further understanding the pathophysiology of cancer.

The potent cytotoxicity of compounds USYDS1 and compound USYDS2 may be explained in terms of their increased hydrophobicity, as demonstrated by their calculated Log partition coefficient ($\text{Log } P$) values. USYDS1 and USYDS2 have $\text{Log } P$ values almost twice that of the hydroxystilbene resveratrol. The effects of $\text{Log } P$ on therapeutic compounds relate primarily to tissue penetration and distribution. Higher $\text{Log } P$ values will enable compounds to more easily cross cell membranes and enter cells.

In other preliminary experiments, particular examples of O- and C- prenylated hydroxystilbene derivatives were found to exhibit concentration dependent inhibition of the SIRT1 enzyme, a member of the Sirtuin family of proteins (silent information regulator two proteins, Sir 2).

Sirtuins have emerged as critical regulators for ageing and longevity in model organisms. Studies into genetics and physiology of sirtuins have shown that this enzyme family plays a role in a variety of cellular processes, including gene silencing, cell death, fatty acid metabolism, neuronal protection and life span extension.

Without being bound to any particular theory, it is proposed that modulation of SIRT1 activity could lead to the development of therapeutic agents for the treatment of diseases including cancer, metabolic syndrome, obesity, neurodegenerative disorder and aging-related diseases.

In a preferred embodiment, according to the fifteenth or sixteenth aspects the compound of formula (Ia) is chemically synthesised. In another preferred embodiment the compound of formula (Ia) is isolated from propolis, wherein the propolis originates from plants of the *Lepidosperma* genus. In yet another preferred embodiment, the

compound of formula (Ia) is isolated from the resin, gum or exudate of the *Lepidosperma* genus.

5 According to the twentieth aspect, in the preparation of compounds of the formula (Ib), (Ic), (Id), (Ie) or (If), preferably the condensation reaction in step (ii) is carried out in the presence of a palladium catalyst. Preferably the palladium catalyst is palladium (II) acetate.

10 Preferably, the alkylation reaction in step (iii) is carried out in the presence of a metal hydride and a halogenated prenyl reagent. Preferably the metal hydride is sodium hydride; however, it would be appreciated by the person skilled in the art that other known metal hydrides can be used. Most preferably the halogenated prenyl reagent is $\text{BrCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$.

15 In a preferred embodiment, the hydrogenation reaction in step (iv) or (vi) is carried out in the presence of a palladium catalyst in a mixture of solvents. Most preferably the palladium catalyst is palladium on carbon and the mixture of solvents comprises 1,4-cyclohexadiene and ethanol. However, it would be appreciated by the person skilled in the art that any other suitable reagents and solvents can be used.

20 In a preferred embodiment, the rearrangement reaction in step (v) is carried out in the presence of magnesium silicate particles (Florisil[®]), silica or alumina particles. In another preferred embodiment the rearrangement reaction can be carried out in the presence of microwave radiation or light. In yet another preferred embodiment, the
25 rearrangement reaction in step (v) is carried out in the presence of magnesium silicate particles (Florisil[®]), silica or alumina particles and in the presence of microwave radiation or light.

Brief Description of the Figures

30 **Figure 1** is a compilation of some of the isolated and synthesised prenylated polyhydroxystilbene derivatives.

35 **Figure 2** is a scheme summarising the synthesis of the novel O- and C- prenylated polyhydroxystilbenes derivatives.

Figure 3 exhibits dose response curves for the inhibition of human cancerous cell growth, for various cell lines, by compound USYDS1.

5 **Figure 4** exhibits dose response curves for the inhibition of human cancerous cell growth, for various cell lines, by compound USYDS2.

Figure 5 exhibits dose response curves for the inhibition of human cancerous cell growth, for various cell lines, by compound USYDS13.

10 **Figure 6** exhibits dose response curves for the inhibition of human cancerous cell growth, for various cell lines, by compound USYDS4.

15 **Figure 7** exhibits dose response curves for the inhibition of human cancerous cell growth, for various cell lines, by compound USYDS9.

Figure 8 exhibits dose response curves for the inhibition of human cancerous cell growth, for various cell lines, by compound USYDS6.

20 **Figure 9** exhibits dose response curves for the inhibition of human cancerous cell growth, for various cell lines, by compound USYDS7.

Figure 10. graphically represents the effect of stilbene compounds on free radical scavenging.

25 **Figure 11.** graphically represents the concentration dependent inhibition of the NAD-dependent deacetylase sirtuin-2 (SIRT1) enzyme by stilbene compounds.

Modes for Carrying Out the Invention

In order to better understand the nature of the invention a number of examples will now be described as follows:

5 **Materials**

Honey bees observed collecting from the sedges (*Lepidosperma viscidum*) were captured in plastic tubes, capped and frozen. Sections of the bee hind legs holding propolis were cut and pooled. Resin from plants were collected and stored at –20°C
10 until analysis. Plant samples were obtained and dried at 40°C in a ventilated oven (Thermoline, NSW Australia) overnight to provide voucher specimens for identification by botanist, A/Prof Murray Henwood, John Ray Museum, University of Sydney, Sydney, Australia, and registered as *Lepidosperma viscidum* chemotype 1a, voucher number Duke 100222-42 and *Lepidosperma viscidum* chemotype 2a, voucher
15 number Duke 100221-21.

76 Beehives made up of 3 10-frame boxes each fitted with a propolis mat under the hive cover lid were used to collect propolis samples. The individually numbered hives were used on location in the apiary sites situated in the central southern region of
20 Kangaroo Island.

Thin layer chromatography sheets precoated with silica gel 60 F₂₅₄ and silica gel 60H for normal-phase short-column chromatography (NPSCC) were purchased from Merck. TLC plates were visualized with a UVGL-58 mineral-light lamp, Multiband UV-
25 2544/366.

All the chemicals used in the isolation and synthesis, including deuterated NMR solvents such as chloroform-*d* and methanol-*d*₄, deuterated dimethyl sulfoxide (d₆-dimethyl sulfoxide) were purchased from Sigma-Aldrich Pty Ltd (Castle Hill, NSW,
30 Australia). Solvents including hexane, dichloromethane, ethyl acetate, isopropanol, ethanol, methanol, and acetic acid were of analytical grade and purchased from Ajax Fine Chem, Taren Point, NSW, Australia. or Asia Pacific Specialty Chemical Ltd (APS).

35 Rotavapor model R-114 rotary evaporator with a water bath temperature ranging between 40-60°C was used to evaporate the solvent fraction. Vacuum pump V-700 or

Vacuubrand MD 4C NT diaphragm pump (Vacuubrand GMBH, Wertheim, Germany) with vacuum controller V-800 or V-850 is used. Final drying is carried out by a Napco 5831 vacuum oven (NAPCO, Salt Lake City, USA) using a DirectTorr vacuum pump (Sargent-Welch, Buffalo, USA).

5

Preparative HPLC was performed on a Shimadzu preparative gradient LC-8A system on a reversed-phase column (Grace, Alltima C18 5 μ M 22 mm ID $\times$ 250 mm), injection volume 500 μ L, eluted with methanol (75%) and water at 10 mL/min and detected at 280 nm with a UV-Vis detector (Shimadzu SPD-20A). Analytical HPLC was performed on Shimadzu UFLC, LC-20AD pump, SIL-20A HT autosampler, with a Hewlett-Packard Column, NUCLEOSIL 100C18, 5 μ m, 4 mm $\times$ 125 mm, injection volume 20 μ L, eluted with methanol-water-acetic acid (70:29.8:0.2) at 1 mL/min and detected at 230 nm with a UV-Vis detector (Shimadzu SPD-20A).

¹H and ¹³C Nuclear magnetic resonance (NMR) analyses were carried out on Varian 400 MHz System with a SMS autosampler (Palo Alto, California, USA). NMR spectra were referenced to tetramethylsilane (TMS). Mass spectra were obtained from a ThermoFinnigan TSQ 7000 (LC-MS/MS system) and a Finnigan Polaris Ion Trap MS/MS system (Finnigan, San Jose, USA) using an Xcalibur 1.2 data system.

20

Determination of the ¹H-NMR chemical profiles of the plant and propolis specimens

Resin samples from the base of stem (0.1 g), bee hind leg (0.01 g) and beehive propolis (1.0 g) were extracted with ethyl acetate at room temperature for 15 min. The extracts were filtered, dried under reduced pressure and analyzed by ¹H-NMR and HPLC. Samples from the sedge type-1 were found to contain prenylated hydroxystilbenes and cinnamates as major constituents, whereas those from sedge type-2 showed only prenylated stilbenes as major constituents as discussed above. Propolis samples were subsequently selected for isolation of the components.

30

Isolation and identification of prenylated polyhydroxystilbenes from propolis of Kangaroo Island.

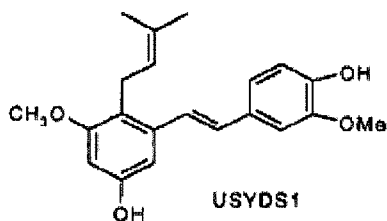
General method

Propolis (10 g) was extracted with dichloromethane at room temperature with stirring for 1 hr. The extract was subjected to purification using normal-phase short column

chromatography (NPSCC). A step-wise gradient of mobile phase (2 x 100 mL) consisting of dichloromethane (DCM) and ethyl acetate (EtOAc) at 0, 1, 2, 4, 8, 10, 15, 20, 50 and 100% was employed to elute the components which were analysed by TLC and NMR. Further purification of the compounds, if required, was subsequently carried out on the same NPSCC with different mobile phases consisting of either hexane and EtOAc or hexane and isopropanol. Normal-phase preparative HPLC was also employed when required to further purify the compounds (Shimadzu LC-8A). The compounds were eluted through a silica column (Altima® silica 10 µm, 10 cm x 250 cm) at a flow rate of 10 mL/min with a mobile phase of 2% isopropanol in hexane at ambient temperature. The elution of compounds was monitored with a UV detector (UV/Vis SPD-20A) at 280 nm. Structures and identity of these purified compounds were characterized by ¹H- and ¹³C-NMR and mass spectrometry including high resolution mass spectrometry. Detailed structural analyses of the isolated compound were also carried out when needed by 2D-NMR using Gradient Heteronuclear Multiple Bond Coherence (GHMBC).

Isolated prenylated polyhydroxystilbene derivatives:

(*E*)-2-(3-methyl-2-buten-1-yl)-4',5-dihydroxy-3,3'-dimethoxystilbene (USYDS1).

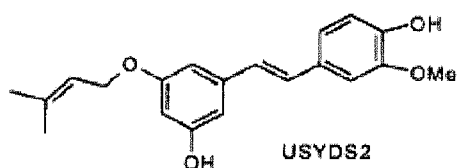


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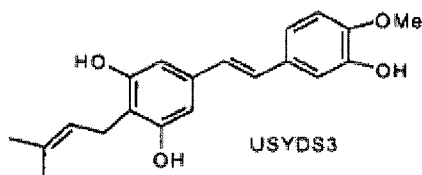
Light yellow liquid. C₂₁H₂₄O₄ ¹H NMR (methanol-*d*₄, 400 MHz): R_f 14.64 min. δ 7.16 (d, *J*=16 Hz, H), 7.07 (d, *J*=4 Hz, H), 6.94 (dd, *J*=8, 4 Hz, H), 6.86 (d, *J*=19 Hz, H), 6.78 (d, *J*=8 Hz, H), 6.63 (d, *J*=4 Hz, H), 6.34 (d, *J*=4 Hz, H), 5.06 (m, H), 3.89 (s, 3H), 3.77 (s, 3H), 3.39 (m, 2H), 1.80 (bs, 3H), 1.66 (bs, 3H). ¹³C-NMR (CDCl₃, 100 MHz) δ 158.5, 154.4, 146.7, 145.6, 138.1, 130.6, 130.4, 130.3, 124.3, 123.7, 120.7, 120.6, 114.5, 108.2, 103.9, 98.2, 55.9, 55.7, 25.8, 24.5, 18.0; Cl-MS: *m/z* 339 (M-1)⁻, HRESIMS: *m/z* 341.1749 (M+H)⁺, calcd 341.1747 for C₂₁H₂₅O₄.

25

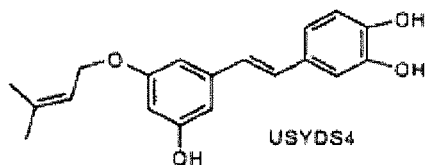
30

(E)-3-(3-methyl-2-butenyloxy)-4',5-dihydroxy-3'-methoxystilbene (USYDS2).

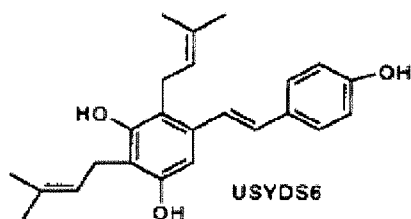
Light yellow liquid. $C_{20}H_{22}O_4$ 1H NMR (methanol- d_4 , 400 MHz): R_t 15.46 min. δ 7.12 (d, $J=4$ Hz, 1H), 7.01 (d, $J=16$ Hz, 1H), 6.97 (dd, $J=8$, 4 Hz, 1H), 6.88 (d, $J=16$ Hz, 1H), 6.78 (d, $J=8$ Hz, 2H), 6.56 (m, 1H), 6.24 (m, 1H), 5.46 (m, 1H), 4.52 (d, $J=4$ Hz, 2H), 3.90 (s, 3H), 1.79 (bs, 3H), 1.76 (bs, 3H). ^{13}C -NMR ($CDCl_3$, 100 MHz) δ 160.2, 156.9, 146.7, 145.5, 139.9, 138.6, 129.9, 129.2, 126.2, 120.6, 119.4, 114.7, 108.4, 105.9, 105.4, 101.5, 65.0, 55.9, 25.8, 18.2; CI-MS m/z 325 ($M-1$) $^-$, HRESIMS m/z 327.15938 ($M+H$) $^+$, calcd 327.1591 for $C_{20}H_{23}O_4$.

10 **(E)-4-(3-methyl-2-buten-1-yl)-3,3',5-trihydroxy-4'-methoxystilbene (USYDS3).**

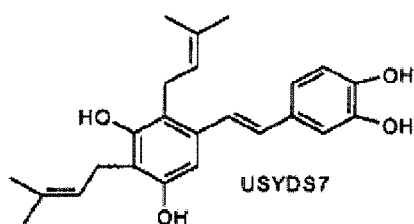
Light yellow liquid. $C_{20}H_{22}O_4$ 1H NMR (methanol- d_4 , 400 MHz): R_t 11.46 min. δ 7.08 (d, $J=4$ Hz, 1H), 6.93 (dd, $J=8$, 4 Hz, 1H), 6.91 (d, $J=16$ Hz, 1H), 6.78 (d, $J=16$ Hz, 1H), 6.77 (d, $J=8$ Hz, 1H), 6.46 (s, 2H), 5.23 (m, 1H), 3.89 (s, 3H), 3.28 (m, 2H), 1.76 (bs, 3H), 1.65 (bs, 3H); CI-MS: m/z 325 ($M-1$) $^-$; HRMS: 325.14453 [$M-1$] $^-$, (calculated 325.14398 for $C_{20}H_{21}O_4$).

(E)-3-(3-methyl-2-butenyloxy)-3',4',5-trihydroxystilbene (USYDS4).

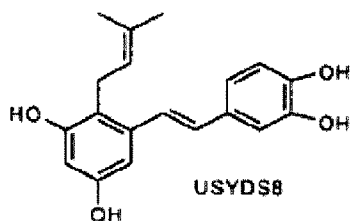
Light yellow liquid. $C_{19}H_{20}O_4$ 1H NMR (methanol- d_4 , 400 MHz): R_t 18.62 min. δ 6.98 (d, $J=4$ Hz, 1H), 6.94 (d, $J=16$ Hz, 1H), 6.85 (dd, $J=8$, 4 Hz, 1H), 6.80 (d, $J=16$ Hz, 1H), 6.74 (d, $J=8$ Hz, 1H), 6.53 (m, 2H), 6.23 (m, 1H), 5.46 (m, 1H), 4.51 (d, $J=4$ Hz, 2H), 1.79 (bs, 3H), 1.76 (bs, 3H); ^{13}C NMR (methanol- d_4 , 100 MHz): δ 160.2, 158.2, 145.2, 145.1, 139.8, 136.9, 129.5, 128.5, 125.5, 119.9, 118.8, 114.9, 112.4, 105.2, 103.8, 100.7, 64.4, 24.4, 16.8; CI-MS: m/z 311 ($M-1$) $^-$; HREIMS: m/z 335.1252 ($M+Na$) $^+$, calcd 335.1259 for $C_{19}H_{20}O_4Na$.

(E)-2,4-di(3-methyl-2-buten-1-yl)-3,4',5-trihydroxystilbene (USYDS6).

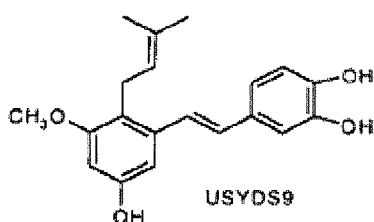
Off-white solid. $C_{24}H_{28}O_3$ 1H NMR (methanol- d_4 , 400 MHz): R_t 9.35 min. δ 7.30 (d, $J=8$ Hz, 2H), 7.11 (d, $J=16$ Hz, 1H), 6.80 (d, $J=16$ Hz, 1H), 6.76 (d, $J=8$ Hz, 2H), 6.63 (s, 1H), 5.21 (m, 1H), 5.10 (m, 1H), 3.41 (m, 2H), 3.35 (m, 2H), 1.81 (bs, 3H), 1.78 (bs, 3H), 1.68 (bs, 6H); CI-MS: m/z 363 ($M-1$) $^-$.

(E)-2,4-di(3-methyl-2-buten-1-yl)-3,3',4',5-tetrahydroxystilbene (USYDS7).

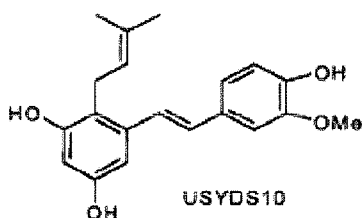
Off-white solid. $C_{24}H_{28}O_4$ 1H NMR (methanol- d_4 , 400 MHz): R_t 10.46 min. δ 7.07 (d, $J=16$ Hz, 1H), 6.94 (d, $J=4$ Hz, 1H), 6.79 (dd, $J=8,4$ Hz, 1H), 6.73 (d, $J=16$ Hz, 1H), 6.71 (d, $J=8$ Hz, 1H), 6.62 (s, 1H), 5.21 (m, 1H), 5.10 (m, 1H), 3.41 (m, 2H), 3.35 (m, 2H), 1.81 (bs, 3H), 1.78 (bs, 3H), 1.68 (bs, 6H); CI-MS: m/z 379 ($M-1$) $^-$; HRMS: 379.19148 [$M-1$] $^-$, (calculated 379.19092 for $C_{24}H_{27}O_4$).

(E)-2-(3-methyl-2-buten-1-yl)-3,3',4',5-tetrahydroxystilbene (USYDS8).

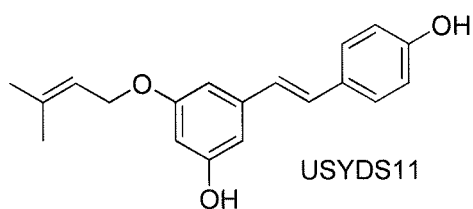
$C_{19}H_{20}O_4$ 1H NMR (acetone- d_6 , 400 MHz): δ 7.07 (d, $J=2$ Hz, 1H), 7.15 (d, $J=16$ Hz, 1H), 6.89 (dd, $J=8, 2$ Hz, 1H), 6.81 (d, $J=8$ Hz, 1H), 6.80 (d, $J=16$ Hz, 1H), 6.63 (d, $J=2$ Hz, 1H), 6.35 (d, $J=2$ Hz, 1H), 5.15 (t, $J=7$ Hz, 1H), 3.42 (d, $J=7$ Hz, 2H), 1.81 (s, 3H), 1.65 (s, 3H). ^{13}C NMR (acetone- d_6 , 100 MHz): δ 155.9, 155.8, 145.4, 145.3, 138.4, 130.1, 129.7, 129.4, 124.5, 123.9, 117.4, 119.0, 115.4, 112.9, 103.4, 101.6, 24.0, 25.0, 17.2. HRESIMS: (m/z) 313.1434 ($M+H$) $^+$, calcd 313.1440 for $C_{19}H_{21}O_4$.

(E)-2-(3-methyl-2-buten-1-yl)-3',4',5-trihydroxy-3-methoxystilbene (USYDS9).

- 5 $C_{20}H_{22}O_4$ 1H NMR (acetone- d_6 , 400 MHz): δ 7.16 (d , J = 16 Hz, 1H), 7.07 (d , J = 2 Hz, 1H), 6.90 (dd , J = 8, 2 Hz, 1H), 6.85 (d , J = 16 Hz, 1H), 6.82 (d , J = 8 Hz, 1H), 6.71 (d , J = 2 Hz, 1H), 6.39 (d , J = 2.3 Hz, 1H), 5.09 (1H, t , J = 7 Hz, 1H), 3.78 (s , 3H), 3.40 (d , J = 7 Hz, 2H), 1.80 (s , 3H), 1.64 (s , 3H). ^{13}C NMR (acetone- d_6 , 100 MHz): δ 158.5, 156.3, 145.3 (2C), 138.0, 130.1, 130.0, 129.6, 123.7, 124.2, 119.1, 118.9, 115.3, 112.9, 103.7, 98.1, 55.0, 25.0, 23.9, 17.2. HRESIMS: m/z
- 10 327.1592 ($M+H$) $^+$, calcd 327.1596 for $C_{20}H_{23}O_4$.

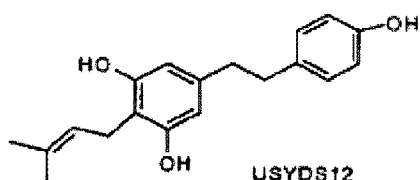
(E)-2-(3-methyl-2-buten-1-yl)-3,4',5-trihydroxy-3'-methoxystilbene (USYDS10).

- 15 $C_{20}H_{22}O_4$ 1H NMR: (acetone- d_6 , 400 MHz) δ 7.13 (d , J = 16 Hz, 1H), 7.02 (dd , J = 8, 2 Hz, 1H), 7.00 (s , 1H), 6.92 (d , J = 8 Hz, 1H), 6.85 (d , J = 16 Hz, 1H), 6.66 (d , J = 2 Hz, 1H), 6.30 (d , J = 2 Hz, 1H), 5.20 (t , J = 7 Hz, 1H), 3.95 (s , 3H), 3.43 (d , J = 7 Hz, 2H), 1.84 (s , 3H), 1.75 (s , 3H). ^{13}C NMR (acetone- d_6 , 100 MHz): δ 155.4, 154.4, 146.7, 145.7, 138.8, 133.6, 131.2, 130.1, 124.2, 122.5, 120.5, 117.7, 114.6, 108.4, 105.3, 102.5, 55.9, 25.8, 25.1, 18.0. HRESIMS: m/z 349.1411
- 20 ($M+Na$) $^+$, calcd 349.1416 for $C_{20}H_{22}O_4Na$.

(E)-3-(3-methyl-2-butenyloxy)-4',5-dihydroxystilbene (USYDS11).

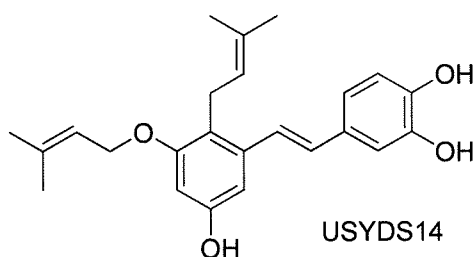
$C_{19}H_{22}O_3$ 1H NMR ($CDCl_3$, 400 MHz): δ 7.38 (*dd*, $J = 7, 2$ Hz, 2H), 7.00 (*d*, $J = 16$ Hz, 1H), 6.84 (*d*, $J = 16$ Hz, 1H), 6.82 (*dd*, $J = 7, 2$ Hz, 2H), 6.64 (*t*, $J = 2$ Hz, 1H), 6.56 (*t*, $J = 2$ Hz, 1H), 6.33 (*t*, $J = 2$ Hz, 1H), 5.50 (*t*, $J = 7$ Hz, 1H), 4.51 (*d*, $J = 7$ Hz, 2H), 1.81 (*s*, 3H), 1.76 (*s*, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 160.4, 156.7, 155.4, 139.9, 138.4, 130.1, 128.8, 128.0 (2C), 126.3, 119.5, 115.6 (2C), 105.6, 105.5, 101.3, 64.9, 25.8, 18.2.

4-(3-methyl-2-buten-1-yl)-3,4',5-trihydroxydihydrostilbene (USYDS12).

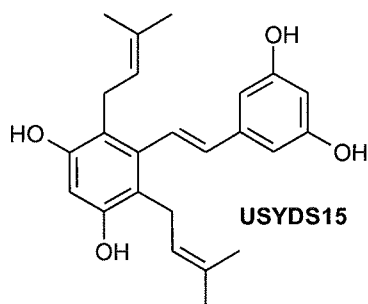


$C_{19}H_{22}O_4$ 1H NMR: (CD_3OD , 400 MHz) δ 6.97 (*d*, $J = 8$ Hz, 2H), 6.66 (*d*, $J = 8$ Hz, 2H), 6.13 (*s*, 2H), 5.22 (*t*, $J = 7$ Hz, 1H), 3.24 (*d*, $J = 7$ Hz, 2H), 2.72 (*m*, 2H), 2.64 (*m*, 2H), 1.74 (*s*, 3H), 1.64 (*s*, 3H). ^{13}C NMR (CD_3OD , 100 MHz): δ 155.5 (2C), 154.9, 140.3, 132.9, 129.4, 128.9 (2C), 123.6, 114.6 (2C), 112.3, 106.5 (2C), 38.0, 36.8, 24.5, 21.7, 16.5.

(E)-2-(3-methyl-2-buten-1-yl)-3-(3-methyl-2-butenyloxy)-3',4',5-trihydroxystilbene (USYDS14).



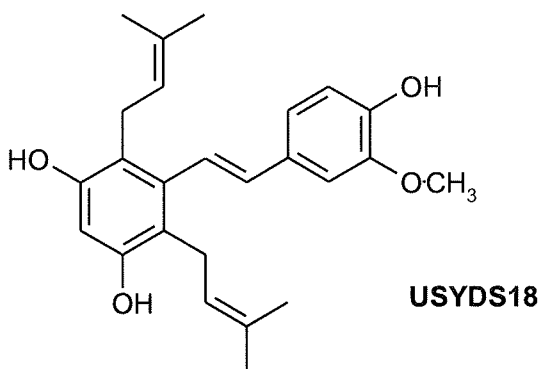
Colourless solid, yield 12 mg. ESI-MS: m/z 379 $[M - 1]^-$, 1H -NMR (methanol- d_4 400 MHz): δ 7.07 (*d*, $J=16$ Hz, 1H), 6.96 (*d*, $J=4$ Hz, 1H), 6.80 (*dd*, $J= 8, 4$ Hz, 1H), 6.79 (*d*, $J=16$ Hz, 1H), 6.74 (*d*, $J=8$ Hz, 1 H), 6.61 (*d*, $J=4$ Hz, 1H), 6.32 (*d*, $J=4$ Hz, 1H), 5.47 (*m*, 1H), 5.06 (*m*, 1H), 4.48 (*m*, 2H), 3.37 (*m*, 2H), 1.78 (*m*, 6H), 1.75 (*m*, 3H), 1.66 (*m*, 3H). ^{13}C -NMR (100 MHz, CD_3OD): δ 16.75, 16.80, 23.84, 24.45, 24.54, 64.86, 99.04, 103.41, 112.39, 114.96, 118.71, 119.14, 120.14, 123.54, 123.97, 129.51, 129.70, 130.01, 136.78, 137.95, 145.08, 145.09, 155.59, 157.47. HRMS: 379.19148 $[M - 1]^-$, (calculated 379.19092 for $C_{24}H_{27}O_4$).

(E)-2,6-di(3-methyl-2-buten-1-yl)-3,3',5,5'-tetrahydroxystilbene USYDS15

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Colourless solid, yield 9 mg. ESI-MS: m/z 379 $[M - 1]^-$, 1H NMR (methanol- d_4 , 400 MHz): δ 6.91 (s, 1H), 6.82 (d, $J=16$ Hz, 1H), 6.73 (, 1H), 6.72 (s, 1H), 6.28 (s, 1H), 6.27 (d, $J=16$ Hz, 1H), 5.12 (m, 1H), 3.26 (m, 2H), 1.65 (m, 6H), 1.59 (m, 6H). ^{13}C -NMR (100 MHz, CD_3OD): δ 16.75, 24.53, 25.60, 112.27, 114.86, 117.66, 118.24, 124.06, 124.63, , 130.20, 133.33, 139.41, 144.73, 144.97, 153.04. HRMS: 379.19149 $[M - 1]^-$, (calculated 379.19092 for $C_{24}H_{27}O_4$).

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(E)-2,6-di(3-methyl-2-buten-1-yl)-3,4',5-trihydroxy-3'-methoxystilbene USYDS18

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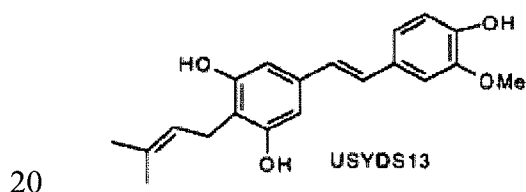
Yield 5 mg. ESI-MS: m/z 393 $[M - 1]^-$. ^1H NMR: (CD_3OD , 400 MHz) δ 7.03 (d , $J = 2$ Hz, 1H), 6.87 (d , $J = 17$ Hz, 1H), 6.85 (dd , $J = 8, 2$ Hz, 1H), 6.77 (d , $J = 8$ Hz, 1H), 6.33 (d , $J = 17$ Hz, 1H), 6.30 (s , 1H), 5.14 ($br\ t$, $J = 6$ Hz, 2H), 3.88 (s , 3H), 3.26 ($br\ d$, $J = 6$ Hz, 4H), 1.66 ($br\ s$, 6H), 1.60 ($br\ s$, 6H). ^{13}C NMR (CD_3OD , 100 MHz): δ 18.37 (2C), 26.12 (2C), 27.20 (2C), 56.53, 102.58, 110.27, 116.42, 119.23 (2C), 121.03, 126.02 (2C), 126.31, 130.41 (2C), 131.7, 134.87, 140.95, 147.51, 149.26, 154.65 (2C). HRMS: 417.20363 $[M + 23]^+$, (calculated 417.20418 for $\text{C}_{25}\text{H}_{30}\text{O}_4\text{Na}$).

Chemical modification and synthesis of prenylated polyhydroxystilbenes

10 A. Rearrangement of O-prenyl to C-prenyl polyhydroxystilbene

A mixture of USYDS2 (5 mg) and Florisil (5 mg) in xylene (2 ml) was heated at 120°C for 30 min in a microwave reactor (CEM Discover Microwave). The product was dried under reduced pressure and purified using NPSCC. Two rearrangement products were observed in a combined yield of approximately 30%.

The major product observed was (*E*)-4-(3-methyl-2-buten-1-yl)-3,4',5-trihydroxy-3'-methoxystilbene (USDYS13):



The minor product observed was (*E*)-2-(3-methyl-2-buten-1-yl)-3,4',5-trihydroxy-3'-methoxystilbene (USYDS10).

25 B. Synthesis of prenylated polyhydroxystilbenes

1. Preparation of 3,5-dihydroxybenzoic acid methyl ester (1)

To a solution of 3,5-dihydroxybenzoic acid (10 g, 64.9 mmol) in anhydrous methanol (150 mL) acetyl chloride (2 mL, 28.1 mmol) was added dropwise. The mixture was heated at reflux under N_2 for 17 hours. The solvent was evaporated and the residue was dissolved in ethyl acetate (100 mL), then washed with saturated sodium hydrogen carbonate (3 x 100 mL). The combined organic layers were washed with water (2 x

100 mL), dried over sodium sulfate, filtered and concentrated *in vacuo* to afford **2** as a colourless solid (9.80 g, 90%): mp 167-168°C (lit.¹ mp 168-169°C); ¹H NMR (400 MHz, Acetone-*d*₆) δ 8.66 (s, 2H), 7.00 (d, *J* = 2.4 Hz, 2H), 6.59 (t, *J* = 2.4 Hz, 2H), 3.83 (s, 3H).

5

2. Preparation of 3-hydroxy-5-benzyloxybenzoic acid methyl ester (2)

To a suspension of NaH (60% dispersion in mineral oil, 3.3 g, 137.3 mmol) in anhydrous N,N-dimethylformamide (DMF) (100 mL) was added a solution of **2** (10 g, 59.5 mmol) in anhydrous DMF (30 mL) at 0°C under N₂, followed by the dropwise
 10 addition of benzyl bromide (6.4 mL, 53.8 mmol). The reaction mixture was stirred at room temperature for 2 hours, quenched with cold water (50 mL), acidified with cold 1 M HCl (20 mL) and extracted with diethyl ether (3 x 50 mL). The combined organic extracts were washed with water (2 x 50 mL), dried over sodium sulfate, filtered and evaporated *in vacuo*. The product was purified using NPSCC using a step-wise gradient
 15 consisting of chloroform/ethanol to afford **2** as an off-white solid (4.5 g, 60%)²: mp 97-98°C (lit.³ mp 98°C); C₁₅H₁₄O₄ ¹H NMR (400 MHz, CDCl₃) δ 8.01 (s, 1H), 7.43-7.33 (m, 5H), 7.24 (dd, *J* = 2.0, 1.2 Hz, 1H), 7.20 (dd, *J* = 2.0, 1.2 Hz, 1H), 6.70 (t, *J* = 2.0 Hz, 1H), 5.07 (s, 2H), 3.90 (s, 3H).

3. Preparation of 3-hydroxy-5-benzyloxybenzoic acid (3)

To a solution of **2** (4.5 g, 16.7 mmol) in methanol (30 mL) was added 1 M NaOH (60 mL, 60 mmol). The resulting reaction mixture was stirred at 45°C for 4 hours under N₂, followed by the addition of 1 M HCl (50 mL) to acidify the solution before extraction with ethyl acetate (3 x 40 mL). The combined organic extracts were washed
 25 with water (2 x 30 mL) and dried over sodium sulfate. The solvent was evaporated *in vacuo* to afford **3** as an off-white solid (4.02 g, 94%): mp 196-198°C; C₁₄H₁₂O₄ ¹H NMR (400 MHz, Acetone-*d*₆) δ 7.42-7.33 (m, 5H), 7.21 (dd, *J* = 2.4, 1.2 Hz, 1H), 7.11 (dd, *J* = 2.4, 1.2 Hz, 1H), 6.68 (t, *J* = 2.4 Hz, 1H), 5.07 (s, 2H).

4. Preparation of 3-hydroxy-5-methoxybenzoic acid (4).

The title compound was prepared as described above by using methyl iodide instead of benzyl bromide to afford **4** as an off-white solid, mp 199-200°C (lit.⁴ mp 199-200°C); C₈H₈O₄ ¹H NMR (400 MHz, Acetone-*d*₆) δ 8.01 (s, 2H), 7.16 (t, *J* = 1.2 Hz, 1H), 7.13 (t, *J* = 1.2 Hz, 1H), 6.15 (t, *J* = 2.4 Hz, 1H), 3.82 (s, 3H).

35

5. Preparation of 3-acetoxy-5-benzyloxybenzoic acid (5)

To the solution of **3** (4.02 g, 17.6 mmol) in acetic anhydride (20 mL, 21.6 mmol) was added pyridine (10%, 0.15 mL, 1.76 mmol). The mixture was stirred at room temperature for 4 hours, quenched with water (30 mL), acidified by 0.1 M HCl (10 mL) and extracted with ethyl acetate (3 × 40 mL). The combined organic extracts were washed with water (2 x 30 mL), dried over sodium sulfate and filtered. The solvent was evaporated *in vacuo* and recrystallised from a mixture (1:1) of hexane/ethyl acetate to afford **5** as pinkish crystals (3.86 g, 96%)⁵: mp 133-134°C; C₁₆H₁₄O₅ ¹H NMR (400 MHz, CDCl₃) δ 7.59 (dd, *J* = 2.4, 1.2 Hz, 1H), 7.45 (dd, *J* = 2.4, 1.2 Hz, 1H), 7.43-7.34 (m, 5H), 6.99 (t, *J* = 2.4 Hz, 1H), 5.1 (s, 2H), 2.32 (s, 3H).

6. Preparation of 3-acetoxy-5-methoxybenzoic acid (**6**)

The title compound was prepared as described in **5** was used to give **6** as an off white solid: mp 151-153°C; C₁₀H₁₀O₅ ¹H NMR (400 MHz, CDCl₃) δ 7.50 (dd, *J* = 2.0, 1.4 Hz, 1H), 7.43 (dd, *J* = 2.0, 1.4 Hz, 1H), 6.90 (t, *J* = 2.0 Hz, 1H), 3.86 (s, 3H), 2.32 (s, 3H).

7. Preparation of 3-methoxy-4-benzyloxybenzaldehyde (**7**)

To a suspension of NaH (60% dispersion in mineral oil, 1.6g, 66.6 mmol) in anhydrous DMF (50 mL) at 0°C under N₂ was added vanillin (4-hydroxy-3-methoxybenzaldehyde, 4 g, 26.3 mmol) in anhydrous DMF (20 mL) slowly via syringe, followed by the dropwise addition of benzyl bromide (3 mL, 25.2 mmol). The mixture was stirred at room temperature for 4 hours, quenched with cold water (30 mL), acidified with cold 1 M HCl (15 mL) and extracted with diethyl ether (3 x 40 mL). The combined organic extracts were washed with water (2 x 30 mL), dried over sodium sulfate and dried under reduced pressure to afford **7** as a colourless solid (6 g, 92%): mp 60-62°C (lit.⁶ mp 61-62°C); C₁₅H₁₄O₃ ¹H NMR (400 MHz, CDCl₃) δ 9.84 (s, 1H), 7.43-7.31 (m, 7H), 7.00 (d, *J* = 8.4 Hz, 1H), 5.25 (s, 2H), 3.95 (s, 3H).

8. Preparation of 4-methoxy-3-benzyloxybenzaldehyde (**8**)

The title compound was prepared as described in **7** to give **8** as a colourless solid: mp 61-63°C (lit.⁷ mp 61-63°C); C₁₅H₁₄O₃ ¹H NMR (400 MHz, CDCl₃) δ 9.80 (s, 1H), 7.49-7.31 (m, 7H), 7.00 (d, *J* = 8.1 Hz, 1H), 5.20 (s, 2H), 3.97 (s, 3H).

9. Preparation of 4-ethenyl-2-methoxy-1-benzyloxybenzene (**9**).

To a suspension of methyltriphenylphosphonium bromide (6.5 g, 18.2 mmol) in anhydrous tetrahydrofuran (THF) (15 mL) under N₂ at 0°C was added potassium *tert*-

butoxide (2.3 g, 20.5 mmol) and the reaction mixture was warmed to room temperature. A solution of benzyl vanillin (**7**) (4 g, 16.5 mmol) in anhydrous THF (15 mL) was added dropwise and stirred for 2 hours, then quenched with cold water (20 mL), acidified with 0.1 M HCl (20 mL), and extracted with ethyl acetate (3 x 40 mL). The combined organic extracts were washed with 20% aq. sodium chloride (20 mL) then dried under reduced pressure. The product was purified using NPSCC using a step-wise mobile phase consisting of hexane/ethyl acetate to afford **9** as a colourless solid (3.37 g, 85%); mp 53-54°C (lit.⁸ mp 50-51°C); C₁₆H₁₆O₂ ¹H NMR (400 MHz, CDCl₃) δ 7.45-7.28 (m, 5H), 6.99 (d, *J* = 2 Hz, 1H), 6.90 (dd, *J* = 4, 1 Hz, 1H), 6.83 (d, *J* = 4 Hz, 1H), 6.68 (dd, *J* = 17, 1 Hz, 1H), 5.64 (dd, *J* = 17, 1 Hz, 1H), 5.17 (s, 2H), 5.14 (d, *J* = 1 Hz, 1H), 3.92 (s, 3H).

10. Preparation of 5-ethenyl-2-methoxy-1-benzyloxybenzene (**10**).

The title compound was prepared as described in **9** to give **10** as an off-white solid; mp 68-69°C (lit.⁹ mp 68-69°C); C₁₆H₁₆O₂ ¹H NMR (400 MHz, CDCl₃): δ 7.48-7.31 (m, 5H), 7.01 (d, *J* = 2 Hz, 1H), 6.97 (dd, *J* = 8, 2 Hz, 1H), 6.85 (d, *J* = 8 Hz, 1H), 6.64 (dd, *J* = 17, 1 Hz, 1H), 5.56 (dd, *J* = 17, 1 Hz, 1H), 5.17 (s, 2H), 5.12 (d, *J* = 1 Hz, 1H), 3.92 (s, 3H).

11. Preparation of *E*-1-[3-acetoxy-5-benzyloxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (**11**):

To a solution of *N,N*-bis(2,6-diisopropyl) dihydro imidazolium chloride (0.093 g, 10%, 0.217 mmol) and Pd(OAc)₂ (0.048 g, 10%, 0.217 mmol) in xylene (3 mL) under N₂ at room temperature was added the acid chloride of **5** (0.7 g, 2.17 mmol) in xylene 2 mL, followed by the addition of 4-ethylmorpholine (0.04 mL, 0.316 mmol) and reagent **9** (0.627 g, 2.61 mmol) in xylene (3 mL). The mixture was heated at 130°C for 18-22 hours. The solvent was evaporated *in vacuo* and the product was purified using NPSCC (hexane/ethyl acetate 3:1 as mobile phase) to give **11** as a yellow oil (0.33 g, 31.6%); C₃₁H₂₈O₅ ¹H NMR (400 MHz, CDCl₃) δ 7.45-7.28 (m, 13H), 7.06 (d, *J* = 2.0 Hz, 1H), 7.02 (d, *J* = 17 Hz, 1H), 6.97 (dd, *J* = 6, 2 Hz, 1H), 6.89 (m, 1H), 6.62 (t, *J* = 2 Hz, 1H), 5.18 (s, 2H), 5.07 (s, 2H), 3.94 (s, 3H), 2.30 (s, 3H); ¹³C NMR (100MHz, CDCl₃) δ 169.39, 159.78, 151.81, 149.79, 148.32, 139.82, 137.00, 136.57, 130.48, 129.78, 128.63 (2C), 128.58 (2C), 128.10, 127.88, 127.55 (2C), 127.24 (2C), 126.02, 119.98, 113.95, 112.02, 110.50, 109.48, 107.28, 71.0, 70.27, 56.02, 21.19; CI-MS *m/z* (%): 481 (M+1)⁺, 503 (M+Na)⁺; HRMS: *m/z* 503.1828 (M+Na)⁺, calcd 503.1834 for C₃₁H₂₈O₅Na.

12. Preparation of *E*-1-[3-acetoxy-5-benzyloxyphenyl]-2-[3-benzyloxy-4-methoxyphenyl]ethene (12).

The title compound was prepared as described in **11** to condense the acid chloride of **5** with reagent **10**. The product was recrystallised from a mixture (2:1) of hexane / toluene to afford yellowish needle crystals; $C_{31}H_{28}O_5$ mp 133-134°C; 1H NMR (400 MHz, $CDCl_3$) δ 7.49-7.29 (m, 10H), 7.07 (d, J = 2 Hz, 1H), 7.05 (dd, J = 8, 2 Hz, 1H), 6.97 (d, J = 16 Hz, 1H), 6.95 (t, J = 2 Hz, 1H), 6.89 (d, J = 8 Hz, 1H), 6.84 (t, J = 2 Hz, 1H), 6.82 (d, J = 16 Hz, 1H), 6.62 (t, J = 2 Hz, 1H), 5.18 (s, 2H), 5.07 (s, 2H), 3.94 (s, 3H), 2.30 (s, 3H); ^{13}C NMR (100MHz, $CDCl_3$) δ 169.39, 159.76, 151.80, 149.90, 148.34, 139.83, 137.05, 136.58, 129.94, 129.78, 128.64 (2C), 128.60 (2C), 128.11, 127.94, 127.58 (2C), 127.38 (2C), 125.88, 120.59, 112.00, 111.91, 111.81, 110.52, 107.22, 71.16, 70.27, 56.06, 21.18 (CH_3CO); CI-MS m/z 481 ($M+1$)⁺, 503 ($M+Na$)⁺; HRMS m/z 503.1832 ($M+Na$)⁺, calcd 503.1834 for $C_{31}H_{28}O_5Na$.

13. Preparation of *E*-1-[3-acetoxy-5-methoxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (13).

The title compound was prepared as described in **11** to condense the acid chloride of **6** with reagent **9** to give the title compound as an off white solid; mp 104-106°C; $C_{25}H_{24}O_5$ 1H NMR (400 MHz, $CDCl_3$) δ 7.45-7.30 (m, 8H), 7.07 (d, J = 2 Hz, 1H), 7.03 (d, J = 16 Hz, 1H), 6.98 (dd, J = 8, 2 Hz, 1H), 6.90 (d, J = 16 Hz, 1H), 6.88 (m, 1H), 5.18 (s, 2H), 3.95 (s, 3H), 3.83 (s, 3H), 2.31 (s, 3H); ^{13}C NMR (100MHz, $CDCl_3$) δ 169.41, 160.58, 151.83, 149.78, 148.31, 139.76, 137.00, 130.49, 129.72, 128.58 (2C), 127.88, 127.24 (2C), 126.07, 119.97, 113.94, 111.73, 109.67, 109.46, 106.54, 71.01, 56.02, 55.50, 21.18; CI-MS m/z 405 [$M+1$]⁺; HRMS m/z 405.1695 ($M+H$)⁺, calcd 405.1702 for $C_{25}H_{24}O_5$.

14. Preparation of *E*-1-[3-hydroxy-5-benzyloxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (14)

To a solution of stilbene **11** (0.04 g, 0.083 mmol) in mixed solvent (MeOH / THF / H_2O , 3/ 3/ 3 mL) was added NaOH (0.02 g, 0.35 mmol) at 0°C under N_2 . The reaction mixture was warmed up to room temperature and stirred for 3 hours. The solution was acidified with 0.1 M HCl (5 mL) and extracted with ethyl acetate (3 x 20 mL). The combined organic extracts were washed with 20% aq. sodium chloride (10 mL), dried over sodium sulphate and evaporated *in vacuo*. The product was purified using NPSCC (mobile phase of hexane/ethyl acetate) followed by recrystallisation to afford **14** as a

colourless solid (0.016 g, 44.5%); mp 114-115°C; C₂₉H₂₆O₄ ¹H NMR (400 MHz, Methanol-*d*₄) δ 7.45-7.28 (m, 10H), 7.06 (d, *J* = 2 Hz, 1H), 7.00 (d, *J* = 16 Hz, 1H), 6.98 (dd, *J* = 8, 2 Hz, 1H), 6.87 (d, *J* = 8 Hz, 1H), 6.86 (d, *J* = 16 Hz, 1H), 6.71 (t, *J* = 2.0 Hz, 1H), 6.59 (t, *J* = 2 Hz, 1H), 6.38 (t, *J* = 2 Hz, 1H), 5.18 (s, 2H), 5.07 (s, 2H), 3.95 (s, 3H); ¹³C NMR (100 MHz, Methanol-*d*₄) δ 160.29, 156.78, 149.76, 148.19, 139.92, 136.98, 136.84, 130.65, 129.20, 128.61 (2C), 128.57 (2C), 128.02, 127.88, 127.49 (2C), 127.26 (2C), 126.54, 119.94, 113.96, 109.45, 105.97, 105.69, 101.54, 71.02, 70.01, 56.03; CI-MS: 461 (M+Na)⁺, 439 (M+1)⁺; HRMS *m/z* 439.1908 (M+H)⁺, calcd 439.1909 for C₂₉H₂₇O₄.

10

15. Preparation of *E*-1-[3-hydroxy-5-benzyloxyphenyl]-2-[3-benzyloxy-4-methoxyphenyl]ethene (15).

Basic hydrolysis of **12** was carried out as described for compound **14** to give the title compound as a colourless solid; mp 117-119°C; C₂₉H₂₆O₄ ¹H NMR (400 MHz, Methanol-*d*₄) δ 7.49-7.30 (m, 10H), 7.07 (d, *J* = 2.0 Hz, 1H), 7.06 (dd, *J* = 8.4, 2.0 Hz, 1H), 6.96 (d, *J* = 16.0 Hz, 1H), 6.87 (d, *J* = 8.0 Hz, 1H), 6.79 (d, *J* = 16.4 Hz, 1H), 6.99 (t, *J* = 1.6 Hz, 1H), 6.57 (t, *J* = 2.0 Hz, 1H), 6.38 (t, *J* = 2.4 Hz, 1H), 5.19 (s, 2H), 5.07 (s, 2H), 3.90 (s, 3H). ¹³C NMR (100MHz, Methanol-*d*₄) δ 160.20, 158.30, 149.68, 148.25, 139.70, 137.41, 137.31, 130.62, 128.16, 128.07 (2C), 128.05 (2C), 127.52, 127.41 (3C), 127.15 (2C), 126.62, 120.35, 111.95 (2C), 105.67, 104.09, 101.11, 70.88, 69.56, 55.10; CI-MS: *m/z* 461 (M+Na)⁺, 439 (M+1)⁺; HRMS *m/z* 439.1907 (M+H)⁺, calcd 439.1909 for C₂₉H₂₇O₄.

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16. Preparation of *E*-1-[3-hydroxy-5-methoxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (16).

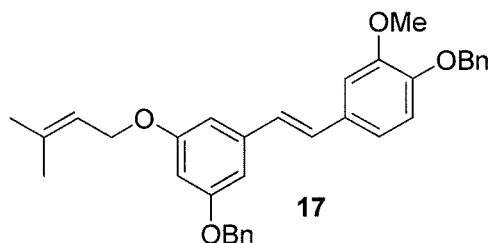
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Basic hydrolysis of **13** was carried out as described for compound **14** to give the title compound as a yellowish solid; mp 110-112°C; C₂₃H₂₂O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.45-7.28 (m, 5H), 7.07 (d, *J* = 2 Hz, 1H), 7.00 (d, *J* = 16 Hz, 1H), 6.98 (dd, *J* = 8, 2 Hz, 1H), 6.87 (d, *J* = 17 Hz, 1H), 6.85 (d, *J* = 8 Hz, 1H), 6.62 (t, *J* = 2 Hz, 1H), 6.57 (t, *J* = 2 Hz, 1H), 6.31 (t, *J* = 2 Hz, 1H), 5.17 (s, 2H), 3.94 (s, 3H), 3.81 (s, 3H); ¹³C NMR (100MHz, CDCl₃) δ 161.08, 156.86, 149.73, 148.16, 139.85, 136.96, 130.69, 129.11, 128.57 (2C), 127.90, 127.29 (2C), 126.61, 119.95, 113.97, 109.47, 105.72, 104.73, 100.72, 71.03, 56.03, 55.36; CI-MS, *m/z* 384 (M+Na)⁺, 363 (M+1)⁺; HRMS *m/z* 363.1592 (M+H)⁺, calcd 363.1596 for C₂₃H₂₃O₄.

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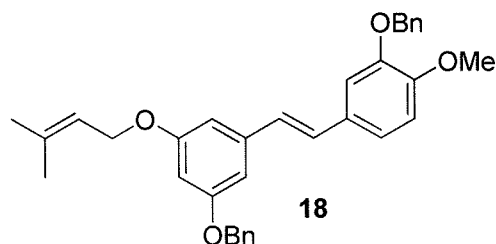
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17. Preparation of *E*-1-[3-(3-methyl-2-butenyloxy)-5-benzyloxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (17)



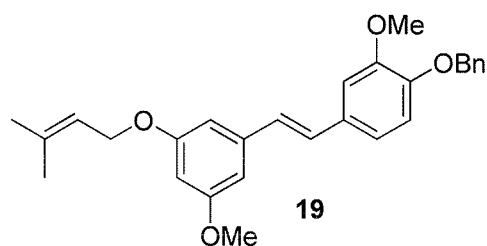
5 To the suspension of NaH (60% dispersion in mineral oil, 0.0051 g, 0.213 mmol) in anhydrous DMF (5 mL) under N₂ at 0°C, stilbene **14** (0.04 g, 0.091 mmol) was added dropwise in DMF (3 mL), followed by the dropwise addition of 3,3-dimethylallyl bromide (0.011 mL, 0.091 mmol).² The mixture was stirred at room temperature for 2-3 hours, then quenched with cold water (5 mL), acidified with cooled 0.1 M HCl (5 mL) and extracted with diethyl ether (3 x 10 mL). The combined organic extracts were washed with water (2 x 10 mL) and dried under reduced pressure. The product was purified using NPSCC (hexane/ethyl acetate as mobile phase) to give **17** as a yellowish oil (0.02 g, 43.3 %); C₃₄H₃₄O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.46-7.28 (m, 10H), 7.07 (d, *J* = 2 Hz, 1H), 7.01 (d, *J* = 16 Hz, 1H), 6.96 (d, *J* = 2 Hz, 1H), 6.90 (d, *J* = 16 Hz, 1H), 6.87 (d, *J* = 8 Hz, 1H), 6.73 (t, *J* = 2 Hz, 1H), 6.68 (t, *J* = 2 Hz, 1H), 6.48 (t, *J* = 2 Hz, 1H), 5.52 (m, 1H), 5.17 (s, 2H), 5.07 (s, 2H), 4.52 (d, *J* = 7 Hz, 2H), 3.95 (s, 3H), 1.80 (d, *J* = 1 Hz, 3H), 1.76 (d, *J* = 1 Hz, 3H); ¹³C NMR (100MHz, CDCl₃) δ 160.21, 160.12, 149.78, 148.14, 139.49, 138.35, 137.03, 136.94, 130.76, 128.94, 128.59 (2C), 128.56 (2C), 127.94, 127.86, 127.54 (2C), 127.24 (2C), 126.97, 119.87, 119.53, 113.98, 109.43, 105.38, 105.32, 101.14, 71.01, 70.09, 64.84, 56.03, 25.85, 18.22; CI-MS: *m/z* 529 (M+Na)⁺, 507 (M+1)⁺; HRMS *m/z* 507.2528 (M+H)⁺, calcd 507.2535 for C₃₄H₃₅O₄.

18. Preparation of *E*-1-[3-(3-methyl-2-butenyloxy)-5-benzyloxyphenyl]-2-[3-benzyloxy-4-methoxyphenyl]ethene (18).



Prenylation of **15** was carried out as described for compound **17** to give the title compound as an off white solid; mp 88-90°C; C₃₄H₃₄O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.49-7.32 (m, 10H), 7.08 (d, *J* = 2 Hz, 1H), 7.06 (dd, *J* = 8, 2 Hz, 1H), 6.97 (d, *J* = 16 Hz, 1H), 6.89 (d, *J* = 8 Hz, 1H), 6.82 (d, *J* = 16 Hz, 1H), 6.71 (t, *J* = 2 Hz, 1H), 6.66 (t, *J* = 2 Hz, 1H), 6.47 (t, *J* = 2 Hz, 1H), 5.53 (m, 1H), 5.20 (s, 2H), 5.07 (s, 2H), 4.52 (d, *J* = 6 Hz, 2H), 3.91 (s, 3H), 1.80 (d, *J* = 1 Hz, 3H), 1.75 (d, *J* = 1 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 161.04, 160.95, 150.51, 149.11, 140.24, 139.03, 137.81, 137.67, 130.91, 129.57, 129.27 (4C), 128.66, 128.58, 128.22 (2C), 128.05 (2C), 127.50, 121.10, 120.20, 112.48, 112.40, 105.95, 105.86, 101.60, 71.55, 70.47, 65.18, 56.36, 26.00, 18.33; CI-MS: *m/z* 529 (M+Na)⁺, 507 (M+1)⁺; HRMS *m/z* 507.2530 (M+H)⁺, calcd 507.2535 for C₃₄H₃₅O₄.

19. Preparation of *E*-1-[3-(3-methyl-2-butenyloxy)-5-methoxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (19).



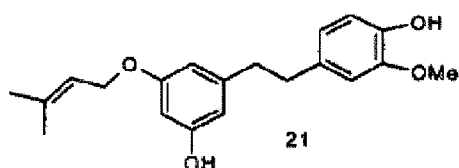
Prenylation of **16** was carried out as described for compound **17** to give the title compound as off white crystal; mp 66-69°C; C₂₈H₃₀O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.45-7.28 (m, 5H), 7.08 (d, *J* = 2 Hz, 1H), 7.02 (d, *J* = 16 Hz, 1H), 6.98 (d, *J* = 2 Hz, 1H), 6.90 (d, *J* = 16 Hz, 1H), 6.87 (d, *J* = 8 Hz, 1H), 6.67 (t, *J* = 2 Hz, 1H), 6.64 (t, *J* = 2 Hz, 1H), 6.40 (t, *J* = 2 Hz, 1H), 5.53 (m, 1H), 5.17 (s, 2H), 4.53 (d, *J* = 7 Hz, 2H), 3.96 (s, 3H), 3.81 (s, 3H), 1.81 (d, *J* = 1 Hz, 3H), 1.76 (d, *J* = 1 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 160.91, 160.23, 149.76, 148.14, 139.46, 138.35, 137.04, 130.78, 128.90, 128.56 (2C), 127.87, 127.25 (2C), 127.02, 119.86, 119.56, 113.98, 109.44, 104.96, 104.49, 100.37, 71.02, 64.82, 56.04, 55.36, 25.86, 18.22; CI-MS: *m/z* 453 (M+Na)⁺; HRMS *m/z* 453.2036 (M+Na)⁺, calcd 453.2042 for C₂₈H₃₀O₄Na.

20. Preparation of (*E*)-3-(3-methyl-2-butenyloxy)-4',5'-dihydroxy-3'-methoxystilbene (20, equivalent to USYDS2)

To a solution of **17** (0.02 g, 0.035 mmol) in absolute ethanol (8 mL), was added 1,4-cyclohexadiene (3 mL, 0.030 mmol) and Pd-C (10%, 0.002 g). The mixture was stirred under N₂ and refluxed at 80°C for 4 hours. The solution was filtered and dried under

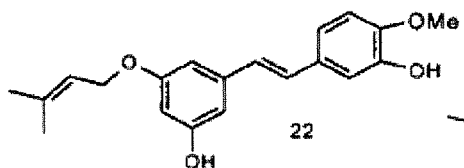
reduced pressure to give an oil residue which was purified by high performance liquid chromatography (HPLC) to afford **20** as a yellowish oil; C₂₀H₂₂O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.02 (d, *J* = 2 Hz, 1H), 7.00 (d, *J* = 16 Hz, 1H), 6.99 (d, *J* = 2 Hz, 1H), 6.91 (dd, *J* = 8, 1 Hz, 1H), 6.85 (d, *J* = 16 Hz, 1H), 6.64 (t, *J* = 2 Hz, 1H), 6.56 (t, *J* = 2 Hz, 1H), 6.33 (t, *J* = 2 Hz, 1H), 5.53 (m, 1H), 4.52 (d, *J* = 7 Hz, 2H), 3.95 (s, 3H), 1.82 (d, *J* = 1 Hz, 3H), 1.76 (d, *J* = 1 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 160.38, 156.70, 146.67, 145.69, 139.87, 138.37, 129.73, 129.29, 126.15, 120.63, 119.49, 114.54, 108.24, 105.58, 105.38, 101.29, 64.85, 55.92, 25.85, 18.22; CI-MS: *m/z* 325 (M-1)⁻; HRMS *m/z* 327.1588 (M+H)⁺, calcd 327.1596 for C₂₀H₂₃O₄.

21. Preparation of 3-(3-methyl-2-butenyloxy)-4',5-dihydroxy-3'-methoxydihydrostilbene (21).



The title compound was obtained by hydrogenation of the double bond on the bridging C=C during removal of the benzyl group of compound **20**. The title compound was obtained as a light yellow oil; C₂₀H₂₄O₄ ¹H NMR (400 MHz, CDCl₃) δ 6.84 (d, *J* = 8 Hz, 1H), 6.69 (dd, *J* = 8, 2 Hz, 1H), 6.62 (d, *J* = 2 Hz, 1H), 6.34 (t, *J* = 2 Hz, 1H), 6.26 (t, *J* = 2.0 Hz, 1H), 6.24 (t, *J* = 2 Hz, 1H), 5.46 (m, 1H), 5.46 (s, 1H), 4.68 (s, 1H), 4.53 (d, *J* = 7 Hz, 2H), 3.84 (s, 3H), 2.85 (m, 4H), 1.80 (d, *J* = 0.4 Hz, 3H), 1.73 (d, *J* = 0.5 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 160.11, 156.44, 146.22, 144.46, 143.73, 138.23, 133.61, 120.95, 119.55, 114.15, 111.10, 107.89, 107.58, 99.62, 64.72, 55.84, 38.29, 37.23, 25.84, 18.18; CI-MS: *m/z* 351 (M+Na)⁺; HRMS *m/z* 351.1566 (M+Na)⁺, calcd 351.1572 for C₂₀H₂₄O₄Na.

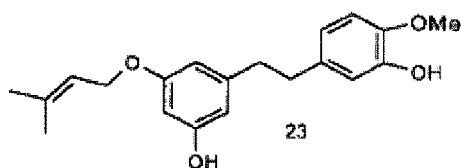
22. Preparation of (E)-3-(3-methyl-2-butenyloxy)-3',5-dihydroxy-4'-methoxystilbene (22).



Removal of benzyl group of **18** was carried out as described for compound **20** to give the title compound as a light yellow oil; C₂₀H₂₂O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.13

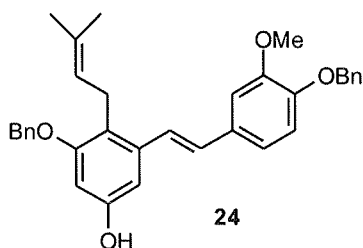
(d, $J = 2$ Hz, 1H), 6.98 (d, $J = 16$ Hz, 1H), 6.97 (dd, $J = 8, 2$ Hz, 1H), 6.86 (d, $J = 8$ Hz, 1H), 6.86 (d, $J = 16$ Hz, 1H), 6.64 (t, $J = 2$ Hz, 1H), 6.57 (t, $J = 2$ Hz, 1H), 6.33 (t, $J = 2$ Hz, 1H), 5.60 (s, 1H), 5.52 (m, 1H), 4.77 (s, 1H), 4.52 (d, $J = 9$ Hz, 2H), 3.91 (s, 3H), 1.82 (d, $J = 1$ Hz, 3H), 1.76 (d, $J = 1$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 160.37, 156.69, 146.51, 145.75, 139.83, 138.36, 130.87, 128.92, 126.78, 119.51, 119.40, 111.84, 110.62, 105.66, 105.48, 101.33, 65.18, 56.36, 26.00, 18.33; CI-MS: m/z 349.1408 ($\text{M}+\text{Na}$) $^+$, calcd 349.1416 for $\text{C}_{20}\text{H}_{22}\text{O}_4\text{Na}$.

23. Preparation of 3-(3-methyl-2-butenyloxy)-3',5-dihydroxy-4'-methoxydihydrostilbene (23).



The title compound was obtained by hydrogenation of double bond on the side chain during removal of the benzyl groups of compound **18**. The title compound was obtained as a light yellow oil; $\text{C}_{20}\text{H}_{24}\text{O}_4$ ^1H NMR (400 MHz, CDCl_3) δ 6.79 (d, $J = 2$ Hz, 1H), 6.77 (d, $J = 4$ Hz, 1H), 6.66 (dd, $J = 8, 2$ Hz, 1H), 6.35 (t, $J = 2$ Hz, 1H), 6.27 (m, 1H), 5.56 (s, 1H), 5.50 (m, 1H), 4.74 (s, 1H), 4.46 (d, $J = 7$ Hz, 2H), 3.88 (s, 3H), 2.80 (m, 4H), 1.80 (d, $J = 1$ Hz, 3H), 1.74 (d, $J = 1$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 160.11, 156.42, 145.41, 144.80, 144.51, 138.18, 135.07, 119.73, 119.59, 114.59, 110.55, 107.81, 107.49, 99.64, 64.73, 55.00, 38.05, 36.89, 25.83, 18.18; CI-MS: m/z 351 ($\text{M}+\text{Na}$) $^+$; HRMS m/z 351.1566 ($\text{M}+\text{Na}$) $^+$, calcd 351.1572 for $\text{C}_{20}\text{H}_{24}\text{O}_4\text{Na}$.

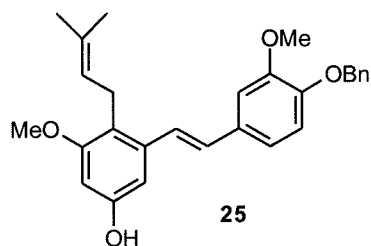
24. Preparation of *E*-1-[2-(3-methyl-2-butenyl)-5-hydroxy-3-benzyloxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (24)



To a solution of **17** (0.024 g, 0.061 mmol) in toluene (30 mL) was added 100-200 mesh Florisil (0.24 g, 10x) and heated at 110°C under N₂ for 4 hours. The reaction mixture was filtered, evaporated *in vacuo* and the red-brown residue was purified using NPSCC (hexane / ethyl acetate as mobile phase) to afford a brownish solid (0.014 g, 58.3 %).

- 5 The product was recrystallised from hexane/ethyl acetate (3:1) mixture to give **24** as an off white solid; mp 145-150°C; C₃₄H₃₄O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.46-7.28 (m, 10H), 7.20 (d, *J* = 16 Hz, 1H), 7.06 (d, *J* = 2 Hz, 1H), 6.97 (dd, *J* = 8, 2 Hz, 1H), 6.88 (d, *J* = 16 Hz, 1H), 6.87 (d, *J* = 8 Hz, 1H), 6.68 (d, *J* = 2 Hz, 1H), 6.40 (d, *J* = 2 Hz, 1H), 5.18 (s, 2H), 5.17 (m, 1H), 5.05 (s, 2H), 4.69 (s, 1H), 3.94 (s, 3H), 3.48 (d, *J* = 7 Hz, 2H), 1.73 (d, *J* = 1 Hz, 3H), 1.67 (d, *J* = 1 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 157.60, 154.27, 149.76, 148.08, 138.31, 137.14, 137.04, 131.18, 130.59, 130.35, 128.56 (2C), 128.49 (2C), 127.86, 127.78, 127.23 (2C), 127.21 (2C), 124.74, 123.63, 121.13, 119.85, 113.99, 109.47, 104.31, 99.53, 71.03, 70.29, 55.98, 25.77, 24.69, 18.01.

- 15 **25. Preparation of *E*-1-[2-(3-methyl-2-butenyl)-5-hydroxy-3-methoxyphenyl]-2-[3-methoxy-4-benzyloxyphenyl]ethene (**25**).**



- 20 Rearrangement of **19** was carried out as described for compound **24** to give a pinkish solid; mp 161-162°C; C₂₈H₃₀O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.46-7.28 (m, 5H), 7.19 (d, *J* = 16 Hz, 1H), 7.06 (d, *J* = 2 Hz, 1H), 6.97 (dd, *J* = 8, 2 Hz, 1H), 6.88 (d, *J* = 16 Hz, 1H), 6.87 (d, *J* = 8 Hz, 1H), 6.66 (t, *J* = 2 Hz, 1H), 6.40 (t, *J* = 2 Hz, 1H), 5.18 (s, 2H), 5.13 (m, 1H), 4.64 (s, 1H), 3.94 (s, 3H), 3.80 (s, 3H), 3.42 (d, *J* = 6 Hz, 2H), 1.80 (d, *J* = 1 Hz, 3H), 1.68 (d, *J* = 1 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 158.56, 154.35, 149.76, 148.07, 138.11, 137.04, 131.21, 130.63, 130.24, 128.56 (2C), 127.86, 127.22 (2C), 124.73, 123.61, 120.78, 119.84, 113.99, 109.42, 103.88, 98.21, 71.03, 55.97, 55.68, 25.77, 24.46, 17.98; CI-MS: *m/z* 453 (M+Na)⁺, 431 (M+1)⁺; HRMS *m/z* 431.2217 (M+1)⁺, calcd 431.2222 for C₂₈H₃₁O₄.

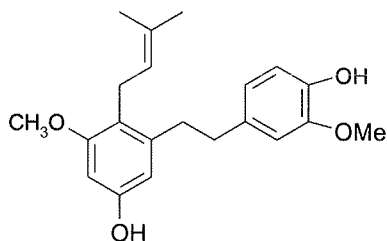
26. Preparation of (*E*)-2-(3-methyl-2-buten-1-yl)-3,4',5-trihydroxy-3'-methoxy-stilbene (26, equivalent to USYDS10).

To a solution of **24** (0.02 g, 0.035 mmol) in absolute ethanol (6 mL) was added 1,4-cyclohexadiene (3 mL) and Pd-C (10%, 0.0035 mmol). The mixture was stirred under N₂ and heated at 80°C for 4 hours. The solution was filtered and evaporated *in vacuo* to give an oil residue which was purified using NPSCC (hexane/ethyl acetate as mobile phase) followed by normal phase HPLC (2:1 hexane/ isopropanol as mobile phase) to afford the title compound as a light yellow oil: Data analogous to that of USYDS10..

27. Preparation of (*E*)-2-(3-methyl-2-buten-1-yl)-5,4'-dihydroxy-3',3-dimethoxy-stilbene (27, equivalent to USYDS1).

The title compound was prepared using the procedure as described for compound **25** to give **27** as light yellow oil; C₂₁H₂₄O₄ ¹H NMR (400 MHz, CDCl₃) δ 7.17 (d, *J* = 16 Hz, 1H), 7.01 (dd, *J* = 12, 2 Hz, 1H), 7.0 (d, *J* = 2 Hz, 1H), 6.91 (d, *J* = 8 Hz, 1H), 6.87 (d, *J* = 16 Hz, 1H), 6.66 (t, *J* = 2 Hz, 1H), 6.36 (t, *J* = 2 Hz, 1H), 5.15 (m, 1H), 4.64 (s, 1H), 3.94 (s, 3H), 3.80 (s, 3H), 3.42 (d, *J* = 7 Hz, 2H), 1.81 (d, *J* = 1 Hz, 3H), 1.68 (d, *J* = 1 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 158.57, 154.37, 146.68, 145.60, 138.18, 130.61, 130.44, 130.27, 124.28, 123.67, 120.73, 120.58, 114.55, 108.26, 103.88, 98.18, 55.88, 55.71, 25.79, 24.48, 17.98; CI-MS: *m/z* 339 (M-1)⁻; HRMS *m/z* 363.1566 (M+Na)⁺, calcd 363.1572 for C₂₁H₂₄O₄Na.

28. Preparation of 2-(3-methyl-2-buten-1-yl)-5,4'-dihydroxy-3',3-dimethoxydihydro-stilbene (28).



The title compound was obtained by hydrogenation of double bond on the side chain during removal of the benzyl group of compound **27**. The title compound was obtained as a light yellow oil; C₂₁H₂₆O₄ ¹H NMR (400 MHz, CDCl₃) δ 6.86 (d, *J* = 8 Hz, 1H), 6.70 (dd, *J* = 8, 2 Hz, 1H), 6.64 (d, *J* = 2 Hz, 1H), 6.30 (d, *J* = 2 Hz, 1H), 6.24 (d, *J* = 2

Hz, 1H), 5.48 (s, 1H), 5.07 (m, 1H), 4.67 (s, 1H), 3.85 (s, 3H), 3.78 (s, 3H), 3.28 (d, J = 6 Hz, 2H), 2.82 (m, 4H), 1.74 (d, J = 1 Hz, 3H), 1.66 (d, J = 1 Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 158.63, 154.23, 146.23, 143.73, 142.01, 133.93, 130.59, 123.87, 120.92, 120.67, 114.21, 111.02, 107.96, 96.90, 55.84, 55.60, 37.19, 35.49, 25.76, 24.38, 17.95; CI-MS: m/z 365 ($\text{M}+\text{Na}$) $^+$; HRMS m/z 365.1723 ($\text{M}+\text{Na}$) $^+$, calcd 365.1729 for $\text{C}_{21}\text{H}_{26}\text{O}_4\text{Na}$.

Biological evaluations of prenylated polyhydroxystilbene derivatives

10 **1. Anticancer activities of the prenylated polyhydroxystilbene derivatives.**

A) Seven prenylated polyhydroxystilbene derivatives, namely USYDS to USYDS7 were evaluated for inhibition of cell growth, as shown in tables 1-3 below, against the 60 cell lines at a range of concentrations (1×10^{-8} – 1×10^{-4} M) at the National Cancer Institute (NCI), USA.

Methodology of the in vitro cancer screen: General method adopted from NCI

The human tumor cell lines were grown in RPMI 1640 medium containing 5% fetal bovine serum and 2 mM L-glutamine. For a typical experiment, cells were inoculated into 96 well microtiter plates in 100 μL at plating densities ranging from 5,000 to 40,000 cells/well depending on the doubling time of individual cell lines. After cell inoculation, the microtiter plates were incubated at 37°C, 5% CO_2 , 95% air and 100% relative humidity for 24 h prior to addition of the drugs.

After 24 h, two plates of each cell line were fixed *in situ* with trichloroacetic acid (TCA), to represent a measurement of the cell population for each cell line at the time of drug addition. Experimental drugs are solubilized in dimethyl sulfoxide (DMSO) at 400-fold the desired final maximum test concentration and stored frozen prior to use. At the time of drug addition, an aliquot of frozen concentrate was thawed and diluted to twice the desired final maximum test concentration with complete medium containing 50 $\mu\text{g/mL}$ gentamicin. Aliquots of 100 μL of the drug were added to the appropriate microtiter wells already containing 100 μL of medium, resulting in the required final drug concentrations.

Following drug addition, the plates were incubated for an additional 48 h at 37°C, 5% CO_2 , 95% air, and 100% relative humidity. For adherent cells, the assay was terminated

by the addition of cold TCA. Cells were fixed *in situ* by the gentle addition of 50 μ L of cold 50 % (w/v) TCA (final concentration, 10 % TCA) and incubated for 60 minutes at 4°C. The supernatant was discarded, and the plates were washed five times with tap water and air dried. Sulforhodamine B (SRB) solution (100 μ L) at 0.4% (w/v) in 1% acetic acid was added to each well, and plates were incubated for 10 minutes at room temperature. After staining, unbound dye was removed by washing five times with 1% acetic acid and the plates were air dried. Bound stain was subsequently solubilized with 10 mM trizma base, and the absorbance was read on an automated plate reader at a wavelength of 515 nm. For suspension cells, the methodology was the same except that the assay was terminated by fixing settled cells at the bottom of the wells by gently adding 50 μ L of 80% TCA (final concentration, 16% TCA), and the absorbance was read on an automated plate reader at a wavelength of 515 nm. The GI₅₀ value (concentration required for 50% inhibition of cell growth), TGI value (concentration required for total inhibition of cell growth) and LC₅₀ value (concentration required for 50% cell lethality or death) were calculated for each of USYDS1 to USYDS7 and the results are presented in tables 1 to 3 below.

Table 1: Effect of pPHOS USYDS1, USYDS2 and USYDS3 on human cancerous cells growth.

Compounds	USYDS1 (μ M)			USYDS2 (μ M)			USYDS3 (μ M)		
Leukemia	GI ₅₀	TGI	LC ₅₀	GI ₅₀	TGI	LC ₅₀	GI ₅₀	TGI	LC ₅₀
CCRF-CEM	0.35	24.6	>100	5.06	>100	>100	6.56	>100	>100
HL-60 (TB)	0.02	0.06	68.9	1.34	9.77	>100	2.55	17.1	>100
K-562	0.04	11.7	>100	0.48	>100	>100	4.08	57.5	>100
MOLT-4	0.43	12.3	80.2	4.16	28.3	>100	2.95	13.7	>100
RPMI-8226	0.11	14.8	>100	4.32	52.8	>100	9.05	51.6	>100
SR	0.04	24.4	>100	0.54	>100	>100	2.80	>100	>100
Non-Small Cell Lung Cancer									
A549/ATCC	0.50	11.3	40.3	3.28	13.0	42.1	4.01	20.4	>100
EKVX	10.8	24.3	54.4	9.04	25.2	66.4	12.8	54.6	>100
HOP-62	0.44	16.0	42.2	4.44	18.5	43.4	5.66	20.4	53.7
HOP-92	0.06	12.3	39.6	3.98	21.1	60.1	5.96	30.5	>100
NCI-H226	3.13	13.3	45.6	5.43	19.1	46.4	10.9	50.1	>100
NCI-H23	0.28	15.1	62.5	2.89	23.6	>100	5.66	28.0	>100
NCI-H322M	11.8	25.7	55.9	9.64	22.7	52.3	5.90	28.5	>100
NCI-H460	0.23	1.38	42.0	2.47	10.9	58.7	3.09	15.6	>100
NCI-H522	0.02	-	44.8	1.14	3.57	14.7	2.13	59.8	25.6
Colon Cancer									
COLO 205	3.86	16.1	42.6	17.3	31.7	57.9	15.6	28.9	53.8
HCC-2998	1.07	11.5	35.8	4.61	17.3	46.4	11.0	30.6	85.3
HCT-116	0.30	11.1	40.4	2.09	11.9	40.0	4.33	15.6	45.6
HCT-15	0.05	16.1	>100	0.76	17.8	97.3	4.25	20.5	84.5
HT29	4.73	15.3	44.4	17.4	32.2	59.6	17.8	36.9	76.8

KM12	0.32	13.9	46.7	2.09	11.7	45.0	3.15	16.1	49.0
SW-620	0.04	15.1	44.3	0.53	14.0	40.7	3.98	15.9	42.8
CNS Cancer									
SF-268	0.25	14.1	50.2	4.50	19.2	51.6	6.17	32.9	>100
SF-295	0.65	16.2	55.7	3.94	14.7	49.2	5.22	23.5	77.5
SF-539	0.04	14.4	48.6	1.92	13.8	50.2	7.32	29.9	>100
SNB-19	0.17	19.3	51.5	5.02	20.4	53.6	8.02	24.2	64.5
SNB-75	0.03	20.2	72.0	2.14	10.3	55.8	5.47	36.6	>100
U251	0.37	10.9	36.0	2.96	14.7	41.0	5.47	20.7	57.6
Melanoma									
LOX IMVI	0.05	16.2	58.8	1.56	19.4	>100	4.48	20.2	80.0
MALME-3M	3.47	25.8	78.3	1.88	26.2	94.9	5.53	32.1	>100
M14	0.04	13.9	44.0	0.53	15.4	49.4	4.92	18.5	51.6
MDA-MB-435	0.03	13.8	43.0	0.34	11.0	41.3	3.08	15.9	>100
SK-MEL-2	0.32	10.6	38.0	1.25	9.59	41.6	3.09	9.37	40.2
SK-MEL-28	10.9	23.8	51.7	5.04	19.4	46.7	5.64	22.5	70.5
SK-MEL-5	0.05	0.75	5.99	1.58	11.5	34.3	2.50	8.54	29.2
UACC-257	2.53	17.7	45.4	7.89	20.6	46.0	5.35	18.1	44.0
UACC-62	1.62	18.3	46.6	3.73	15.9	44.6	5.30	19.7	58.8
Ovarian Cancer									
IGROV1	2.65	27.9	>100	5.84	46.7	>100	6.70	86.2	>100
OVCAR-3	0.26	-	37.3	3.02	10.7	36.1	7.98	39.8	>100
OVCAR-4	0.58	18.4	52.0	5.34	28.0	>100	9.68	74.8	>100
OVCAR-5	6.0	21.4	55.3	10.1	24.8	60.9	13.9	79.3	>100
OVCAR-8	0.08	11.7	50.0	2.80	14.8	44.6	5.48	59.8	>100
ADR-RES	0.03	-	70.7	0.40	4.95	>100	4.41	>100	>100
SK-OV-3	0.19	11.6	34.7	3.69	14.9	38.9	7.96	36.2	>100
Renal Cancer									
786-0	0.48	14.0	>100	3.55	15.9	98.8	5.24	24.5	>100
A498	1.84	8.45	32.2	10.3	23.8	55.2	3.88	21.0	63.5
ACHN	0.07	14.0	44.6	3.76	17.5	52.1	5.11	>100	>100
CAKI-1	4.77	39.3	>100	6.13	>100	>100	5.90	>100	>100
RXF-393	0.03	-	39.1	1.35	5.46	23.6	5.48	18.9	46.5
SN12C	0.99	16.9	54.2	4.02	18.8	60.2	7.16	>100	>100
TK-10	4.10	15.7	40.5	4.69	14.3	40.1	6.98	31.4	>100
UO-31	0.25	16.0	51.3	2.60	16.9	48.9	4.16	38.1	>100
Prostate Cancer									
PC-3	0.42	16.1	47.9	3.84	18.7	65.8	6.36	>100	>100
DU-145	0.06	12.7	38.6	3.05	12.5	37.8	6.82	31.6	>100
Breast Cancer									
MCF7	0.23	13.0	52.9	1.24	15.0	41.0	0.68	19.9	82.7
MDA-MB-231	0.15	2.43	61.2	0.25	2.10	15.7	1.63	7.82	>100
BT-549									
HS 578T	0.02	-	>100	1.28	10.3	>100	2.40	15.0	>100
T-47D	0.72	19.8	67.4	5.66	33.6	>100	2.92	14.7	70.5
MDA-MB-468	0.36	8.37	33.2	2.72	9.41	36.8	1.68	7.63	>100

Table 2: Effect of pPHOS USYDS4 to USYDS6 on human cancerous cells growth

Compounds	USYDS4 (μ M)			USYDS5 (μ M)			USYDS6 (μ M)		
Leukemia	GI ₅₀	TGI	LC ₅₀	GI ₅₀	TGI	LC ₅₀	GI ₅₀	TGI	LC ₅₀
CCRF-CEM	3.50	>100	>100	2.14	>100	>100	2.96	9.17	82.1
HL-60 (TB)	2.59	6.04	>100	0.20	0.43	0.95	2.07	4.83	15.4
K-562	2.35	>100	>100	0.33	13.9	>100	1.46	4.13	22.6
MOLT-4	4.31	21.6	>100	1.27	6.77	>100	1.59	4.27	16.8
RPMI-8226	2.35	25.4	>100	0.45	>100	>100	2.34	5.61	62.0
SR	0.95	>100	>100	-	-	-	-	-	-
Non-Small Cell Lung Cancer									
A549/ATCC	4.74	25.6	>100	2.62	41.5	>100	2.69	8.42	33.7
EKVX	9.55	59.6	>100	26.4	>100	>100	7.19	21.4	54.4
HOP-62	6.49	26.3	83.4	2.87	>100	>100	5.11	17.5	44.0
HOP-92	1.92	13.6	62.3	0.62	>100	>100	1.86	4.67	14.5
NCI-H226	5.14	23.1	78.0	18.6	57.9	>100	1.47	30.1	61.5
NCI-H23	3.42	20.8	81.9	1.43	>100	>100	3.38	15.7	47.6
NCI-H322M	12.8	54.7	>100	0.76	>100	>100	1.16	25.5	56.2
NCI-H460	3.65	20.3	>100	0.47	10.3	75.7	1.89	3.90	8.06
NCI-H522	1.07	2.54	6.04	0.15	0.45	44.8	2.18	5.15	17.8
Colon Cancer									
COLO 205	9.72	23.0	53.5	21.7	83.6	>100	16.0	30.2	57.2
HCC-2998	5.16	19.0	53.4	4.18	21.2	>100	2.81	8.78	32.2
HCT-116	4.55	16.0	40.6	1.40	12.8	75.0	1.89	3.78	7.54
HCT-15	1.77	34.9	>100	0.43	>100	>100	2.13	6.26	48.2
HT29	16.3	32.5	64.7	18.6	46.6	>100	5.44	17.6	48.3
KM12	3.27	14.2	46.5	0.52	12.2	63.9	2.21	4.37	8.64
SW-620	2.97	16.6	46.5	0.31	15.3	75.0	1.84	3.54	6.82
CNS Cancer									
SF-268	3.89	23.2	>100	0.63	37.6	>100	2.78	8.97	44.3
SF-295	7.29	24.3	70.9	2.60	20.5	>100	6.78	20.8	53.2
SF-539	3.45	22.3	97.5	0.28	1.02	>100	4.48	17.6	57.1
SNB-19	10.5	25.8	63.8	0.55	>100	>100	6.38	20.6	52.7
SNB-75	1.77	9.11	48.3	0.24	-	>100	6.67	21.4	54.0
U251	3.67	15.6	45.5	0.59	19.6	>100	2.33	5.31	16.7
Melanoma									
LOX IMVI	3.82	19.3	58.5	0.64	58.6	>100	1.76	3.42	6.68
MALME-3M	7.25	30.6	>100	0.62	>100	>100	2.80	8.56	37.1
M14	0.91	15.4	46.3	0.30	5.69	>100	2.82	8.46	33.4
MDA-MB-435	0.36	21.6	>100	0.13	0.42	>100	3.37	10.8	42.1
SK-MEL-2	2.18	6.57	31.0	2.17	12.1	>100	13.1	33.6	86.1
SK-MEL-28	9.18	27.6	77.9	8.14	>100	>100	11.2	24.0	51.3
SK-MEL-5	1.42	8.35	30.0	0.39	2.52	>100	2.29	6.17	22.1
UACC-257	5.44	19.4	48.6	6.15	59.2	>100	3.49	14.4	39.8
UACC-62	4.53	16.8	44.4	3.22	34.8	>100	10.3	23.5	53.8
Ovarian Cancer									
IGROV1	3.74	44.8	>100	4.57	>100	>100	5.23	17.7	54.1
OVCAR-3	3.98	15.0	44.9	0.90	3.84	24.8	2.10	4.31	8.85
OVCAR-4	3.98	50.4	>100	5.48	>100	>100	4.40	16.1	43.5
OVCAR-5	15.9	51.4	>100	30.7	>100	>100	5.86	20.0	53.3

OVCAR-8	4.94	31.1	>100	0.50	38.3	>100	2.95	9.51	42.9
ADR-RES	1.11	48.3	>100	0.29	3.69	>100	3.46	15.2	51.2
SK-OV-3	8.91	57.0	>100	0.50	5.12	>100	13.9	27.1	53.2
Renal Cancer									
786-0	4.41	20.5	>100	2.99	18.7	>100	2.46	6.96	28.8
A498	9.07	23.5	55.2	10.3	53.5	>100	11.7	25.0	53.1
ACHN	4.57	>100	>100	0.66	>100	>100	3.94	14.6	50.4
CAKI-1	5.25	>100	>100	19.1	>100	>100	8.37	22.6	55.7
RXF-393	2.17	15.3	46.0	0.23	0.63	>100	2.15	5.39	18.7
SN12C	3.94	20.0	74.1	1.76	83.5	>100	2.85	7.98	30.8
TK-10	3.87	9.66	>100	5.34	41.2	>100	3.36	9.33	31.2
UO-31	3.31	20.7	66.4	0.46	>100	>100	2.51	7.50	33.5
Prostate Cancer									
PC-3	4.47	22.0	87.9	2.92	>100	>100	1.80	3.89	8.44
DU-145	6.37	44.6	>100	0.35	2.62	>100	3.47	12.9	40.1
Breast Cancer									
MCF7	2.57	18.2	51.1	2.81	>100	>100	4.02	18.0	60.5
MDA-MB-231	1.04	18.4	>100	0.38	2.61	>100	1.72	4.54	17.2
HS 578T	1.00	7.11	>100	0.20	0.73	>100	1.67	5.29	35.8
T-47D	2.13	6.93	>100	4.78	36.9	>100	5.03	20.3	57.9
MDA-MB-468	2.53	9.51	55.1	2.42	8.48	>100	2.30	6.39	26.0

Table 3: Effect of pPHOS USYDS7 on human cancerous cells growth

Compound	USYDS7 (μM)						
Leukemia	GI ₅₀	TGI	LC ₅₀	Melanoma	GI ₅₀	TGI	LC ₅₀
CCRF-CEM	2.73	8.48	71.2	LOX IMVI	1.71	3.41	6.81
HL-60 (TB)	2.39	5.06	13.8	MALME-3M	1.97	4.46	10.4
K-562	2.14	4.78	17.4	M14	1.79	3.71	7.73
MOLT-4	2.01	5.19	26.5	MDA-MB-435	2.29	6.47	31.7
RPMI-8226	2.31	6.01	61.1	SK-MEL-2	3.20	7.82	42.9
Non-Small Cell Lung Cancer				SK-MEL-28	3.65	11.8	36.7
A549/ATCC	1.88	4.06	8.78	SK-MEL-5	1.80	3.68	7.54
EKVX	4.25	14.7	44.9	UACC-257	2.18	5.93	23.0
HOP-62	3.67	15.0	51.6	UACC-62	2.80	7.84	31.5
HOP-92	1.52	4.21	14.2	Ovarian Cancer			
NCI-H226	2.28	6.24	28.1	IGROV1	3.12	8.39	36.7
NCI-H23	1.81	5.22	29.5	OVCAR-3	1.82	3.36	6.19
NCI-H322M	5.29	18.1	44.7	OVCAR-4	2.85	11.1	66.8
NCI-H460	1.64	3.22	6.33	OVCAR-5	3.04	11.6	39.0
NCI-H522	1.61	3.57	7.92	OVCAR-8	1.68	3.65	7.95
Colon Cancer				ADR-RES	2.23	7.90	42.4
COLO 205	1.79	4.34	12.2	SK-OV-3	5.98	19.4	46.5
HCC-2998	1.95	4.26	9.34	Renal Cancer			
HCT-116	1.57	3.02	5.82	786-0	1.99	4.47	10.2
HCT-15	1.29	3.78	22.0	A498	11.1	23.8	50.8
HT29	3.64	10.8	45.8	ACHN	2.58	9.12	37.6
KM12	1.93	3.88	7.79	CAKI-1	4.24	16.2	49.0
SW-620	1.58	3.19	6.42	RXF-393	1.53	3.23	6.80
CNS Cancer				SN12C	1.65	3.16	6.03

SF-268	2.26	5.47	22.7	TK-10	3.62	11.2	34.3
SF-295	3.37	11.4	44.6	UO-31	1.60	3.46	7.46
SF-539	2.21	6.14	35.2	Breast Cancer			
SNB-19	2.80	8.64	39.9	MCF7	2.10	12.0	57.9
SNB-75	2.98	12.8	49.1	MDA-MB-231	1.49	3.89	10.7
U251	1.49	2.93	5.74	HS 578T	1.84	8.09	50.9
Prostate Cancer				T-47D	1.88	6.09	43.5
PC-3	2.02	4.57	11.3	MDA-MB-468	2.12	4.84	13.9
DU-145	2.65	7.62	28.3				

In summary, all the prenylated polyhydroxystilbene derivatives USYDS1 to USYDS7 exhibited structure dependent inhibition of cancerous cell growth. In some cell lines, growth was inhibited at nano-molar concentrations. USYDS1 displayed the most potent activity followed by USYDS5 then USYDS2 in the inhibition of cancerous cell growth. The other pPHOS compounds tested were shown to be moderate inhibitors. Figures 3 to 9 show dose response curves for the inhibition of human cancerous cell growth, for the various cell lines exhibited in the table above, by compounds USYDS1 to USYDS7.

Worthy of note is that these pPHOS required at least a 10 fold excess in concentration to cause cell death (LC₅₀ values) or cause necrosis, over that required to inhibit cell growth (GI₅₀ values). This indicates that the pPHOS were likely to cause the cancer cells to undergo programmed cell death (apoptosis) or cell cycle arrest.

B) Two prenylated polyhydroxystilbene derivatives, namely USYDS10 and USYDS14 were evaluated for inhibition of cell growth, as shown in Table 4A and 4B below, against the cell lines indicated at a range of concentrations ($1 \times 10^{-8} - 1 \times 10^{-4}$ M) at the National Cancer Institute (NCI), USA.

Table 4A: Inhibitory effect on cancer cells growth of USYDS10

	GI50	TGI	LC50
Leukemia			
HL-60(TB)	3.27E-7	1.88E-6	> 1.00E-4
K-562	3.86E-7	3.17E-5	> 1.00E-4
MOLT	5.96E-7	1.99E-5	> 1.00E-4
RPMI	3.24E-7	1.63E-5	> 1.00E-4
SR	1.88E-7	> 1.00E-4	> 1.00E-4
Non-Small Cell Lung Cancer			
A549/ATCC	6.60E-7	2.25E-5	> 1.00E-4
EKVX	1.22E-5	7.34E-5	> 1.00E-4
HOP	5.81E-7	1.77E-5	4.23E-5

	HOP	3.98E-7	2.63E-5	9.32E-5
	NCI-H226	5.35E-6	3.50E-5	> 1.00E-4
	NCI-H23	3.80E-7	1.52E-5	7.83E-5
	NCI-H322M	1.18E-5	3.14E-5	8.37E-5
5	NCI-H460	3.81E-7	1.29E-5	6.61E-5
	NCI-H522	3.49E-7	1.46E-5	4.22E-5
	Colon Cancer			
	COLO	1.53E-5	2.97E-5	5.77E-5
	HCC-2998	1.81E-6	1.19E-5	3.98E-5
10	HCT-116	4.80E-7	1.30E-5	4.27E-5
	HCT-15	4.98E-7	2.09E-5	> 1.00E-4
	HT29	5.72E-6	2.13E-5	6.90E-5
	KM12	4.97E-7	1.53E-5	8.58E-5
	SW-620	3.62E-7	2.15E-5	8.55E-5
15	CNS Cancer			
	SF-268	1.40E-6	4.96E-5	> 1.00E-4
	SF-295	2.01E-6	1.91E-5	> 1.00E-4
	SF-539	3.76E-7	1.29E-5	4.17E-5
	SNB-19	6.13E-7	2.28E-5	> 1.00E-4
20	SNB-75	2.36E-7	1.22E-5	3.61E-5
	U251	4.19E-7	1.62E-5	7.88E-5
	Melanoma			
	LOX IMVI	5.72E-7	1.93E-5	8.00E-5
	MALME-3M	1.87E-5	4.17E-5	9.29E-5
25	M14	2.84E-7	1.42E-5	4.16E-5
	MDA-MB-435	3.85E-8	2.56E-7	> 1.00E-4
	SK-MEL-2	5.76E-7	3.26E-5	> 1.00E-4
	SK-MEL-28	5.72E-7	1.69E-5	4.30E-5
	SK-MEL-5	2.91E-7	1.27E-5	3.60E-5
30	UACC-257	1.17E-5	2.94E-5	7.37E-5
	UACC-62	5.21E-7	1.55E-5	4.28E-5
	Ovarian Cancer			
	IGROV1	2.03E-6	> 1.00E-4	> 1.00E-4
	OVCAR-3	3.72E-7	2.03E-5	> 1.00E-4
35	OVCAR-4	1.03E-6	1.82E-5	5.77E-5
	OVCAR-5	8.92E-6	2.80E-5	8.31E-5
	OVCAR-8	4.67E-7	6.50E-5	> 1.00E-4
	NCI/ADR-RES	1.83E-7	8.04E-7	> 1.00E-4
	SK-OV-3	4.22E-7	1.14E-5	3.42E-5
40	Renal Cancer			
	786-0	6.81E-7	2.01E-5	7.45E-5
	A498	2.17E-6	7.85E-6	3.48E-5
	ACHN	9.03E-7	3.79E-5	> 1.00E-4
	CAKI-1	5.39E-7	6.68E-5	> 1.00E-4
45	RXF 393	2.21E-7		3.76E-5
	SN12C	6.71E-7	2.98E-5	> 1.00E-4
	TK-10	9.55E-6	5.15E-5	> 1.00E-4
	UO-31	8.78E-7	2.17E-5	9.52E-5

Prostate Cancer				
	PC-3	2.27E-6	3.12E-5	> 1.00E-4
	DU-145	4.42E-7	2.05E-5	> 1.00E-4
Breast Cancer				
5	MCF7	3.32E-7	1.30E-5	5.06E-5
	MDA-MB-231/ATCC	6.42E-7	3.20E-5	> 1.00E-4
	HS 578T	2.92E-7	2.60E-5	> 1.00E-4
	BT-549	7.98E-7	1.90E-5	4.93E-5
	T-47D	1.47E-6	2.47E-5	> 1.00E-4
10	MDA-MB-468	3.73E-7	1.44E-5	4.49E-5

Table 4B - Inhibitory effect on cancer cells growth of USYDS14

15		GI50	TGI	LC50
	Leukemia			
	HL-60(TB)	4.06E-6	1.63E-5	> 1.00E-4
	K-562	8.33E-7	1.42E-5	> 1.00E-4
	MOLT-4	4.03E-6	2.10E-5	> 1.00E-4
20	RPMI-8226	4.07E-6	2.45E-5	> 1.00E-4
	SR	6.70E-7	2.46E-5	> 1.00E-4
	Non-Small Cell Lung Cancer			
	A549/ATCC	4.33E-6	1.65E-5	4.55E-5
	EKVX	6.45E-6	2.12E-5	5.17E-5
25	HOP-62	1.43E-6	3.77E-6	9.98E-6
	HOP-92	1.49E-6	7.58E-6	3.29E-5
	NCI-H226	1.72E-6	3.60E-6	7.52E-6
	NCI-H23	2.92E-6	1.73E-5	5.76E-5
	NCI-H322M	1.25E-5	2.57E-5	5.28E-5
30	NCI-H460	3.87E-6	1.49E-5	5.12E-5
	NCI-H522	7.50E-7	2.26E-6	5.85E-6
	Colon Cancer			
	COLO 205	1.46E-5	2.85E-5	5.57E-5
	HCC-2998	2.90E-6	1.06E-5	4.07E-5
35	HCT-116	4.20E-6	1.60E-5	4.66E-5
	HCT-15	2.06E-6	1.04E-5	4.33E-5
	HT29	1.40E-5	2.91E-5	6.09E-5
	KM12	3.74E-6	1.44E-5	5.74E-5
	SW-620	2.88E-6	1.67E-5	6.38E-5
40	CNS Cancer			
	SF-268	4.65E-6	1.78E-5	4.85E-5
	SF-295	3.91E-6	1.53E-5	4.31E-5
	SF-539	2.96E-6	1.05E-5	3.78E-5
	SNB-19	5.01E-6	2.01E-5	5.22E-5
45	SNB-75	1.79E-6	7.80E-6	2.93E-5
	U251	3.09E-6	1.27E-5	3.94E-5
	Melanoma			
	LOX IMVI	1.36E-6	3.37E-6	8.35E-6

	MALME-3M	3.14E-6	2.18E-5	5.48E-5
	M14	2.95E-6	1.36E-5	5.00E-5
	MDA-MB-435	3.73E-7	8.45E-6	4.00E-5
	SK-MEL-2	3.72E-6	1.25E-5	4.12E-5
5	SK-MEL-28	3.05E-6	1.64E-5	4.16E-5
	SK-MEL-5	5.54E-7	1.87E-6	4.46E-6
	UACC-257	1.02E-5	2.35E-5	5.40E-5
	UACC-62	2.61E-6	1.32E-5	3.91E-5
	Ovarian Cancer			
10	IGROV1	3.65E-6	1.37E-5	6.54E-5
	OVCAR-3	3.52E-6	1.35E-5	4.11E-5
	OVCAR-4	2.98E-6	1.36E-5	3.86E-5
	OVCAR-5	1.24E-5	2.58E-5	5.36E-5
	OVCAR-8	3.59E-6	1.56E-5	6.49E-5
15	NCI/ADR-RES	7.80E-7	1.14E-5	4.93E-5
	SK-OV-3	2.85E-6	1.37E-5	3.72E-5
	Renal Cancer			
	786-0	3.44E-6	1.18E-5	4.00E-5
	A498	1.30E-5	2.66E-5	5.46E-5
20	ACHN	2.98E-6	1.25E-5	3.65E-5
	CAKI-1	3.59E-6	1.75E-5	4.54E-5
	RXF 393	1.07E-6	3.58E-6	1.48E-5
	SN12C	3.61E-6	1.51E-5	4.20E-5
	TK-10	3.79E-6	1.21E-5	3.54E-5
25	UO-31	3.71E-6	1.79E-5	4.63E-5
	Prostate Cancer			
	PC-3	6.65E-6	2.16E-5	5.50E-5
	DU-145	8.20E-6	2.11E-5	4.75E-5
	Breast Cancer			
30	MCF7	2.74E-6	1.18E-5	4.19E-5
	MDA-MB-231/ATCC	3.15E-6	1.43E-5	4.53E-5
	HS 578T	2.71E-6	2.05E-5	> 1.00E-4
	BT-549	4.27E-6	1.63E-5	4.69E-5
	T-47D	2.71E-6	7.84E-6	6.18E-5
35	MDA-MB-468	1.42E-6	4.12E-6	1.64E-5

In summary, all the prenylated polyhydroxystilbene derivatives USYDS10 and USYDS14 exhibited structure dependent inhibition of cancerous cell growth.

40 2. Calculated Log partition coefficients (Log P) values of various hydroxystilbenes.

The calculated Log P values for USYDS1 and USYDS2 and known hydroxystilbenes are presented in the table 5 below.

45 Table 5. Calculated Log *P* values of various hydroxystilbenes

Compound USYDS2	5.37	Rhapontigenin	2.82
Compound USYDS1	5.58	Compound USYDS1 without a prenyl group.	3.49
Resveratrol	3.14	Pinosylvin	3.68
Piceatannol	1.90		

The potent inhibition of pPHOS compounds, for example USYDS1 and USYDS2, may be explained in terms of their increased hydrophobicity, as demonstrated by their calculated Log partition coefficient (Log *P*) values. USYDS1 and USYDS2 have Log *P* values almost twice that of the hydroxystilbene resveratrol. The effects of Log *P* on therapeutic compounds relate primarily to tissue penetration and distribution. Higher Log *P* values will enable compounds to more easily cross cell membranes and enter cells.

3. Effect of prenylated polyhydroxystilbene derivatives on UV-irradiated human skin cells.

Normal adult human keratinocytes (NHK) cells (Invitrogen, Vic, Australia) were cultured in keratinocyte growth medium Epilife supplemented with calcium and human keratinocyte growth supplement (HKGS, containing 0.2 ng EGF per mL, 5 mg insulin per mL, 5 mg transferrin per mL, 0.18 mg hydrocortisone per mL, and 0.2% bovine pituitary extract) (Invitrogen, Vic, Australia) in 12-well culture plates until the subconfluent state is reached. Cells were cultured to a density of 5×10^3 cells per mL/well in a 24-well plate for 24 h at 37°C in a humidified incubator with 5% carbon dioxide and tested according to the protocols described below:

Determination of optimal doses of UV irradiation.

Cells, seeded at a density as described above, were washed twice with PBS (phosphate buffered saline) then irradiated with a range of UVA and UVB doses known as MED (minimal erythema dose, 1 MED = 25.43/light intensity). Cells were replaced with growth medium and incubated for about 24 h at 37°C in a humidified incubator with 5% carbon dioxide. Cell viability was measured using the MTS assay (CellTiter 96[®] AQueous One Solution Cell Proliferation Assay) (Promega, Vic Australia).

Rescue assay.

Cells were washed twice with PBS, replaced with a thin layer of PBS, then irradiated with the optimal doses of UVA and UVB as determined above. Immediately after irradiation, cells were replaced with fresh culture medium containing the test samples at a range of concentrations, and further incubated in a humidified CO₂ incubator at 37°C for 24 hr. Supernatants were collected and kept at –80°C until determination of PGE2 and cytokines (IL1, 6, 8, 10 & 12) concentration using ELISA kits.

Protective assay.

Cells were washed twice with PBS, replaced with a thin layer of PBS containing different concentrations of the test compounds then irradiated with optimal doses of UVA and UVB as determined above. Immediately after irradiation, cells were replaced with fresh culture medium and further incubated in a humidified CO₂ incubator at 37°C for 24 h. Supernatants were be collected and kept at –80°C until determination of PGE2 and cytokines (IL1, 6, 8, 10 & 12) concentration using ELISA kits.

Sham-treated control cultures were handled identically but not exposed to UV irradiation. Stilbenes compounds including USYDS1, 2, 13, 5, and 7 and propolis extract were tested at 0.1, 1 and 10 µM or µg/mL.

Results for the determination of optimal doses of UV irradiation revealed that at 1 MED of UVA and UVB irradiation, there is no significant effect on cell viability. Thus, this condition was chosen for investigation of the effects of stilbenes and propolis extract on levels of cytokines in the rescue assay.

In preliminary investigation on modulation of cytokine productions in UV irradiated human epidermal keratinocytes (HEK) it was observed that a mixture of USYDS1 and USYDS2 moderately inhibit the production of IL-6, TGFα, G-CSF and GM-CSF (2-3 fold). However, it was found that the prenylated polyhydroxystilbene derivatives significantly increased IL-8 and IL-1α production (4-5 fold) from UV irradiated cells. IL-8 is known to play a role in the onset of immunity response. IL-1α (naturally occurring cytokine receptor antagonist) on the other hand plays an important role in inhibition of deleterious effect of IL-1 during inflammatory processes. Therefore, these preliminary results demonstrate that the prenylated polyhydroxystilbene derivatives of the present invention may be good candidates for the treatment of conditions associated with immunity suppression and inflammation.

4. Antioxidant activities of the stilbenes and propolis extracts

1,1-Diphenyl-2-picrylhydrazyl (DPPH[•]) scavenging activity assay

5 The (1,1-diphenyl-2-picrylhydrazyl) DPPH assay is commonly used to test free radical scavenging ability of a compound or extracts of natural products by measurement of the reduction of DPPH[•] radicals at 517 nm. In its radical form, DPPH[•] shows a strong absorption at 517 nm due to its odd electron. Upon reduction by an antioxidant or radical scavenger, the absorption disappears and the resulting decolorization by
10 scavenging the radical is stoichiometric with respect to the number of electrons taken up ($\text{DPPH}^{\bullet} + \text{AH} \rightarrow \text{DPPH:H} + \text{A}^{\bullet}$). The DPPH assay was carried out in a stepwise procedure as described below.

A methanolic solution of DPPH (0.1 mM) was stirred in a dark container at room
15 temperature for 20 min. The solution was scanned between 400 – 750 nm to obtain a maximum wavelength (λ_{max} , ~ 510 nm). The concentration of the DPPH solution was adjusted with methanol to result in a maximum absorbance of approximately 1.0. Test samples at different concentrations and standard antioxidant solution (0.05 mL) were added to 0.95 mL of methanolic DPPH solution in a cuvette. Final concentrations of
20 the test samples were 0.1, 1, 10, 50, 100 and 200 μM . The mixtures were shaken vigorously and allowed to stand in the dark for 30 min at room temperature. Absorbance of the resulting solution was measured at the maximum wavelength (~510 nm). A decrease in absorbance indicated a free radical scavenging effect of the test samples. Dose response curves of the test samples were established to determine their
25 IC_{50} values (concentrations that show 50% reduction in UV absorbance).

Results

pPHOS compounds in this study exhibited a moderate to weak effect on free radical scavenging except for USYDS7 which exhibited a strong effect. These results are
30 displayed in Figure 10.

5. Effect of stilbene derivatives on nicotinamide adenine dinucleotide (NAD)-dependent deacetylase sirtuin-2 (SIRT1).

35 SIRT1 is a member of Sir2 family (class III) which is a NAD-dependent histone deacetylase. Deacetylation by SIRT1 enzyme can target many substrates including

histone, tumor suppressor p53, forkhead transcription factor (FOXO), peroxisome proliferator-activated receptor- γ (PPAR γ) and co-activator-1 α (PGC-1 α).¹⁰ SIRT1 has been shown to be involved in the regulation of many physiopathological processes like inflammation, cellular aging, apoptosis/proliferation, metabolism and cell cycle regulation (Chung, Yao et al. 2010). Accordingly, modulating SIRT1 activity could be a potential therapeutic target to control many diseases such as cancer, metabolic syndrome, obesity, neurodegenerative disorder, skeletal muscle dysfunction and aging-related diseases.¹¹

SIRT1 assay kit (Cayman Chemical, Ann Arbor, Michigan, USA) provides a fluorescence-based method for screening of SIRT1 inhibitors or activators. The assay was carried out according to the instructions from the manufacturer. In brief, the assay consists of two steps, both performed in the same plate. In the first step, the substrate, which comprises the p53 sequence Arg-His-Lys-Lys(ϵ -acetyl)-AMC (7-amino-4-methylcoumarin), is incubated with human recombinant SIRT1 along with its cosubstrate NAD⁺. Deacetylation sensitizes the substrate such that treatment with the developer in the second step releases a fluorescent product which was analysed using fluorometric plate reader at an excitation wavelength of 350-360 nm and an emission wavelength of 450-465 nm. Stilbenes were assayed at three concentrations (1, 10 and 100 μ M). Data represents two independent experiments each performed in triplicate.

Results

All the stilbenes, except resveratrol, exhibited a concentration dependent inhibition of SIRT1 as shown in Figure 11 A and B. Modulation of SIRT1 activity could lead to the development of therapeutic agents for the treatment of diseases including cancer, metabolic syndrome, obesity, neurodegenerative disorder, and aging-related diseases.

6. Antibacterial activities of USYDS1, USYDS2 and ethanolic extract of sedge type-1 propolis

Summary.

The minimum inhibition concentration (MIC) screening was performed with 14 bacterial strains and 4 compounds. The MICs were determined by the broth microdilution method according to the Clinical and Laboratory Standards Institute (CLSI) guidelines. The MIC screening was performed on 96-well plates containing the compounds in serial 2-fold dilutions from 64 to 0.06 μ g/ml. The bacterial inoculations

were prepared in cation-adjusted Mueller Hinton medium broth from cultures grown on appropriate agar plates which are prepared freshly every week. The growth controls and sterile controls were included in each assay plates. The assay plates were incubated in an ambient-air incubator at $35 \pm 2^\circ\text{C}$ for 16-20 hr (24 hr for MRSA), and bacterial growth was observed and recorded. All MICs of reference compound levofloxacin in the MIC screening are within the standard range described in CLSI S100-A20. The potency of 3 test samples is the order of USYDS1 > USYDS2 > ethanolic propolis extract.

10 1. Materials

1.1. Strains

Bacteria panel for MIC screening

Microorganism	Gram	Strain	¹ Resistance	² Plasmid	Cultivation condition	MIC screening condition
Escherichia coli	G ⁻	ATCC (25922)			TSA, ambient air, $35 \pm 2^\circ\text{C}$	CAMHB, ambient air, $35 \pm 2^\circ\text{C}$, 20 hr
Pseudomonas aeruginosa	G ⁻	ATCC (27853)			TSA, ambient air, $35 \pm 2^\circ\text{C}$	CAMHB, ambient air, $35 \pm 2^\circ\text{C}$, 20 hr
Klebsiella pneumoniae	G ⁻	ATCC (700603)	AMP, AZT, CFX, CPD, CAZ, CHL, PIP, TET	Yes	TSA, ambient air, $35 \pm 2^\circ\text{C}$	CAMHB, ambient air, $35 \pm 2^\circ\text{C}$, 20 hr
Haemophilus influenzae	G ⁻	ATCC (49247)			Chocolate agar, 5% CO ₂ , $35 \pm 2^\circ\text{C}$	HTM, ambient air, $35 \pm 2^\circ\text{C}$, 20 hr
Acinetobacter calcoaceticus	G ⁺	ATCC (51432)	IMI		TSA, ambient air, $35 \pm 2^\circ\text{C}$	CAMHB, ambient air, $35 \pm 2^\circ\text{C}$, 20 hr
Enterococcus faecium	G ⁺	ATCC (700221)	VAN		TSA + 5% sheep blood, ambient air, $35 \pm 2^\circ\text{C}$	CAMHB, ambient air, $35 \pm 2^\circ\text{C}$, 20 hr
Enterococcus faecalis	G ⁺	ATCC (29212)			TSA + 5% sheep blood, ambient air, $35 \pm 2^\circ\text{C}$	CAMHB, ambient air, $35 \pm 2^\circ\text{C}$, 20 hr
Streptococcus	G ⁺	ATCC			TSA + 5% sheep	CAMHB + 3% horse

pyogenes		(700492)			blood, 5% CO ₂ , 35 ± 2°C	blood, ambient air, 35±2°C, 20 hr
Streptococcus pneumoniae	G ⁺	ATCC (49619)	PEN		TSA + 5% sheep blood, 5% CO ₂ , 35 ± 2°C	CAMHB + 3% horse blood, ambient air, 35±2°C, 20 hr
Streptococcus pneumoniae	G ⁺	Clinical isolate	ERY		TSA + 5% sheep blood, 5% CO ₂ , 35 ± 2°C	CAMHB + 3% horse blood, ambient air, 35±2°C, 20 hr
Staphylococcus aureus	G ⁺	ATCC (29213)			TSA, ambient air, 35 ± 2°C	CAMHB, ambient air, 35±2°C, 20 hr
Staphylococcus aureus	G ⁺	ATCC (43300)	MET, OXA		TSA, ambient air, 35 ± 2°C	CAMHB, ambient air, 35±2°C, 20 hr
Staphylococcus aureus	G ⁺	Clinical isolate	LEV		TSA, ambient air, 35 ± 2°C	CAMHB, ambient air, 35±2°C, 20 hr
Staphylococcus aureus	G ⁺	Clinical isolate	MET, ERY, CLI		TSA, ambient air, 35 ± 2°C	CAMHB, ambient air, 35±2°C, 20 hr

¹Known resistance; ²Known plasmid presence

Abbreviation: TSA, trypticase soy agar; CAMHB, cation-adjusted Mueller Hinton broth; HTM, Haemophilus test medium; AMP, ampicillin; AZT, aztreonam; CFX, cefoxitin; CPD, cefpodoxime; CAZ, ceftazidime; CHL, chloramphenicol; PIP, piperacillin; TET, tetracycline; IMI, imipenem; VAN, vancomycin; PEN, penicillin; ERY, erythromycin; MET, methicillin; OXA, oxacillin; LEV, levofloxacin; CLI, clindamycin.

10

1.2. Media and reagents

Trypticase soy agar (BD 211043), Cation-adjusted Mueller Hinton broth (BD 212322), Haemophilus test medium base (Fluka 51295), Hemin (Fluka 51280), β-NAD (Fluka 43410), Levofloxacin (Sigma 28266), Sheep blood (Quad Five 630-500), Lysed horse blood (Quad Five 205-500), 0.5 McFarland barium sulfate standard, Sterile 0.85% NaCl (w/v).

15

2. Methods

2.1. Prepare bacterial strains

- A. Revive bacterial strains from storage frozen (-80°C) two days before the MIC screening. Streak onto surface of appropriate agar plates, and incubate the plates for 20-24 hr at $35 \pm 2^\circ\text{C}$ in an appropriate atmosphere.
- Streptococci: TSA II, 5% CO₂
- Enterococci: TSA II, ambient air
- Haemophilus influenzae*: chocolate agar, 5% CO₂
- Other strains in the panel: TSA, ambient air
- B. Select 5-10 well-isolated colonies of similar morphology and restreak onto fresh agar plates using sterile loops. Incubate the plates for 20-24 hr at $35 \pm 2^\circ\text{C}$ in an appropriate atmosphere as above.

2.2. Prepare compound plates

- Compound stock solutions were prepared in 100% DMSO on the day of MIC screening and use immediately. Compound stock concentration = [(highest testing concentration) x 103 µl / 3 µl] (e.g. if the required highest testing concentration is 64 µg/ml in assay plates, stock concentration = $64 \times 103/3 = 2.2$ mg/ml). The potency of testing compound is assumed as 100% unless otherwise stated whereas the potency of reference compound is calculated according to manufacturer's analysis data.
- Eleven two-fold dilutions per compound were made then transferred 3 µl to each well of test plate. Final concentration of DMSO in the MIC screening is ~3%.

2.3. Prepare bacterial inoculation

- A. Take out medium broth from 4°C fridge and allow it to warm to room temperature.
- B. Transfer colonies from fresh culture plates into 5 ml of saline with sterile loops and mix well. Measure and adjust turbidity to 0.5 McFarland barium sulphate standard using a turbidity meter. Alternatively, transfer 1-2 colonies into 500 µl of saline and adjust OD₆₂₅ to ~0.1 using a plate reader.
- C. Dilute bacterial inoculum 1:280 for Gram-positive and fastidious strains and 1:400 for Gram-negative strains into corresponding medium broth (CAMHB, CAMHB+3% lysed horse blood, HTM) (e.g. 35.6 µl of inoculum into 10 ml of CAMHB or 25 µl of inoculum into 10 ml of CAMHB).
- H. influenzae*: HTM
- Streptococci: CAMHB + 3% lysed horse blood
- Other strains in the panel: CAMHB

2.4. Prepare assay plates

A. Add 100 µl of the bacterial inoculum to each well of the compound plates except wells B12, D12, F12 and H12.

5 B. Add 100 µl of medium broth to wells B12, D12, F12 and H12 of the compound plates.

C. Stack four plates together and cover with a sterile plate lid. Incubate in an ambient-air incubator at $35 \pm 2^\circ\text{C}$ for 16-20 hours (24 hours for MRSA).

10 2.5. Perform colony counts

A. Dilute the bacterial inoculum (0.5 McFarland) to a serial of 10⁻¹ to 10⁻⁷ in saline solution (e.g. 100 µl bacterial inoculum + 900 µl of saline).

B. Spread 100 µl of each dilution (10⁻⁴, 10⁻⁵, 10⁻⁶, and 10⁻⁷) onto CAMHA plates in triplication, let the liquid soak into the agar for 10 minutes, invert the agar plates and
15 incubate for 24 hr at $35 \pm 2^\circ\text{C}$.

2.6. Record MICs and calculate CFUs

A. Open the compound plate layout in the compound management system, and check the assay plate barcode.

20 B. Place the assay plate on the top of MIC reader, and adjust the magnification mirror to read each wells, record growth status as raw data. (Optional) Record photo image of each assay plates using high-speed high-resolution scanner.

C. Determine MIC break points according to CLSI guideline.

D. Count colonies and calculate CFU of bacterial inoculum.

25

3. Results

3.1. MIC summary table

The MIC screening was performed with 14 bacterial strains (11 ATCC strains and 3 clinical isolates) and 4 compounds (USYDS1, USYDS2 and ethanolic extract of propolis and reference compound levofloxacin). The MICs are summarized in the
30 below Table 6. The MIC values of reference compound Levofloxacin obtained in this study are within the standard range as described in S100-A20 [2]. The final concentration of DMSO in the MIC screening was ~3%, and did not inhibit the growth of most microorganisms.

35

Table 6. MICs ($\mu\text{g/ml}$) of USYDS1, USYDS2 and ethanolic extract of propolis against fourteen bacterial strains. Levofloxacin is reference compound.

Compounds	Levofloxacin		USYDS1		USYDS2		Ethanolic propolis extract	
	Exp 1	Exp 2	Exp 1	Exp 2	Exp 1	Exp 2	Exp 1	Exp 2
<i>Acinetobacter calcoaceticus</i>	4	4	>64	>64	>64	>64	>64	>64
<i>Escherichia coli</i>	<0.0625	<0.0625	16	16	64	32	>64	>64
<i>Enterococcus faecalis</i> (ATCC 29212)	1	1	16	16	32	32	64	64
<i>Enterococcus faecium</i> (ATCC 700221)	>64	>64	8	16	32	32	64	32
<i>Haemophilus influenzae</i>	<0.0625	<0.0625	32	32	32	32	64	64
<i>Klebsiella pneumoniae</i>	1	1	>64	>64	>64	>64	>64	>64
<i>Pseudomonas aeruginosa</i>	1	1	>64	>64	>64	>64	>64	>64
<i>Staphylococcus aureus</i> (ATCC 29213)	0.5	0.25	16	8	32	16	32	32
<i>Staphylococcus aureus</i> (ATCC 43300)	0.25	0.25	8	8	16	16	32	32
<i>Staphylococcus aureus</i> (Levofloxacin-resistant)	64	64	8	8	16	16	16	16
<i>Staphylococcus aureus</i> (MRSA, Erythromycin & clindamycin-resistant)	8	8	8	8	16	16	32	32
<i>Streptococcus pneumoniae</i> (ATCC 49619)	0.5	0.5	32	32	32	32	32	32
<i>Streptococcus pyogenes</i> (ATCC 700942)	0.5	0.5	64	64	64	64	>64	>64
<i>Streptococcus pneumoniae</i> (Erythromycin-resistant)	1	1	32	32	32	64	64	>64

4. Discussion

The prenylated tetrahydroxystilbenes USYDS1 and USYDS2 showed a moderate anti-bacterial activities with the rank of potency of USYDS1 > USYDS2 > ethanolic extract of propolis.

5

7. The effect of USYDS1, USYDS2 and USYDS10 compounds on kinases activities

The following is a list of kinases in the studied.

No.	Kinase	No.	Kinase	No.	Kinase	No.	Kinase
1	ABL2	20	CDK4/CyclinD3	39	FGFR3	58	PKA γ
2	AKT1	21	CDK5/CyclinP25	40	FGR	59	PKC α
3	AKT2	22	CDK6/CyclinD1	41	FLT1 (VEGFR1)	60	PKC β I
4	AKT3	23	CDK6/CyclinD3	42	FLT3	61	PKC γ
5	ALK1	24	CDK7/CyclinH1/MNAT1	43	GSK3 α	62	PKC ϵ
6	AMPK (A1/B1/G1)	25	CHK1	44	HER2	63	PKC θ
7	AMPK (A2/B1/G1)	26	c-KIT	45	IGF1R	64	PKC δ
8	Aurora A	27	c-KIT(V654A)	46	InsR	65	PKC δ
9	Aurora B	28	EGFR(T790M,L858R)	47	KDR	66	PKC ι
10	Aurora C	29	EphA1	48	LCK	67	PLK2
11	AXL	30	EphA2	49	NEK2	68	PLK3
12	BLK	31	EphA3	50	p38 β	69	RAF1
13	BTK	32	EphA4	51	PDGFR β	70	BRAF
14	CAMK1	33	EphB1	52	PI3K α	71	BRAF(v599E)
15	CDK1/CyclinA2	34	EphB2	53	PI3K β	72	RET
16	CDK1/CyclinB	35	EphB3	54	PI3K γ	73	RON
17	CDK2/CyclinA2	36	ERK1	55	PI3K δ	74	SRC
18	CDK3/CyclinE1	37	FGFR1(V561M)	56	PKA α	75	TrkA
19	CDK4/CyclinD1	38	FGFR2	57	PKA β	76	TrkB

10 Experiments

Materials:

•Kinase-Glo(Plus) / ADP-Gloassay buffer

25 mMHEPES, 10 mM MgCl₂, 0.01% Triton X-100, 100 μ g/mLBSA, 2.5 mM DTT, pH7.4.

15 •Caliper assay buffer

100 mMHEPES, 10 mM MgCl₂, 100 μ L Brij35 (30%), 1 mM DTT, pH7.4.

Assay substrates

•MBP protein, UnactiveMEK1, Rbprotein were purchased from SignalChem. Poly(glu:tyr)(4:1) was purchased from Sigma. PIP2 was purchased from Cayman. Peptide substrates were synthesized in HD Biosciences, China.

- 5 ATP was purchased from Sigma. KinaseGloPlus reagent, KinaseGlo reagent and ADP Glo reagent were purchased from Promega

Assay Procedure -Caliper Format

- 10 Mix Kinases, substrate, ATP and compound in 96-well assay plate, total volume is 50 μ L. Incubate assay plate at 30°C for 1 hour. Stop reaction by adding 20 μ L of 35 mM EDTA and transfer 26 μ L stopped reaction to 384-well assay plate. Read the assay plate on the plate reader.

Assay Procedure –ADP-GloFormat

- 15 Mix Kinases, substrate, ATP and compound in 384-well assay plate, total volume is 10 μ L. Incubate assay plate at 30°C for 1 hour. Add 10 μ L/well of ADP GloReagent to the assay plate, incubate at 27°C for 40 min.

Add 20 μ L/well Detection Reagent to the assay plate, incubate at 27°C for 30 min. Read the assay plate on the plate reader

20

Assay Procedure –Kinase-Glo(Plus)Format

- 25 Mix Kinase, substrate, ATP and compound in 384-well assay plate, total volume is 10 μ L. Incubate assay plate at 30°C for 1 hour. Add 10 μ L/well KinaseGlo(Plus) reagent to the reaction mixture, and then incubate at 27°C for 20 min. Read the assay plate on plate reader.

- Hundred percent effect was performed without compound and enzyme, but containing ATP and substrate.
- Zero percent effect was carried out without compound, but containing ATP, substrate and enzyme.
- 30 •SB202190 is reference compounds for kinase p38 β ; Staurosporine(STSP) is reference compound for the remaining kinases.

Results

- 35 Kinases that inhibited more than 60% are summarised in the table below. It is interesting to note that all three compounds inhibited kinases TrKA and PI3K δ and

PI3K γ . Both USYDS1 and USYDS10 appear to display similar inhibitory activities towards the kinases.

Compound	Kinases
USYDS1	FLT3, TrkA, CDK2/CyclinA2, CDK4/CyclinD3, PI3K α , PI3K δ , PI3K γ
USYDS2	TrkA, PI3K β , PI3K δ , PI3K γ
USYDS10	FLT3, TrkA, KDR, FLT1, CDK2/CyclinA2, PI3K α , PI3K β , PI3K δ , PI3K γ , CDK1/CyclinB

5

8. Acute Toxicity Study of USYDS1

Method

A single mouse is given a single IP injection of 400 mg/kg; a second mouse receives a dose of 200 mg/kg IP and a third mouse receives a single dose of 100 mg/kg IP. The mice are observed for a period of 2 weeks. They are sacrificed if they lose more than 20% of their body weight or if there are other signs of significant toxicity. If all 3 mice must be sacrificed, then the next 3 dose levels (50, 25, 12.5 mg/kg) are tested in a similar way. This process is repeated until a tolerated dose is found. This dose is then designated the maximum tolerated dose (MTD) and is used to calculate the amount of material given to experimental mice during anti-tumor testing. The mice are allowed *ad libitum* feed and water. Drug was dissolved in 100% DMSO at concentration of 200 mg/mL.

Result

Group	Dose (mg/kg/dose)	Route	Death days	Survivor/Total day 15	Injection volume
1	100	IP	None	1/1	0.5 μ L/gm body wt
2	200	IP	1	0/1	1 μ L/gm body wt
3	400	IP	1	0/1	2 μ L/gm body wt

The MTD of USYDS1 was determined as 100 mg/kg. This concentration indicates low mammalian toxicity and is being used for further anti-tumor testing. Hollow fiber

assay (BEC/C) for USYDS1 is under progression. The hollow fibre assay is a preliminary rapid screen for assessing novel putative chemotherapeutic compounds against a range of cancer cell lines prior to their evaluation in the mouse xenograft model. The hollow fiber model has a shorter evaluation time and a reduced compound requirement compared to traditional xenograft models. The model allows for the effective selection of cancer cell types in the xenograft.

Chemotypes of plants that produce resins as sources of prenylated polyhydroxystilbene derivatives

Resins, gums or exudates obtained from plants of the *Lepidosperma* genus from different locations were analysed by quantitative ¹H-NMR (q-NMR) for prenylated polyhydroxystilbene content, which include C- and O-prenylated, O-methylated and non-O-methylated derivatives. Different proportions of these prenylated polyhydroxystilbene derivatives from the resins form a basis to classify the plants accordingly.

There are at least 3 different chemotypes of *Lepidosperma* plants identified thus far and each of these plants display several sub-chemotypes. Type 1 is the most common plant which contains approximately equal proportion of both C- and O-prenylated derivatives. Type 2 plant contains only C-prenylated derivatives. Where as, type 3 plant contains no O-methylated prenylated polyhydroxystilbene derivatives.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

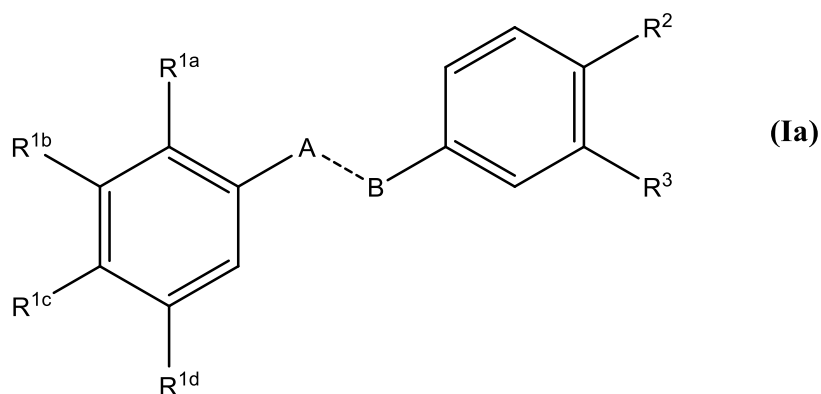
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CLAIMS:

1. Use of the compound of formula (Ia)



or a pharmaceutically acceptable salt or solvate thereof,
wherein:

R^{1a} is $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$;

R^{1b} is selected from OH, OR^4 , or $\text{OCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$;

R^{1c} is selected from H or $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$;

R^{1d} is OH;

R^2 is selected from OH or OR^4 ;

R^3 is selected from OH or OR^4 ;

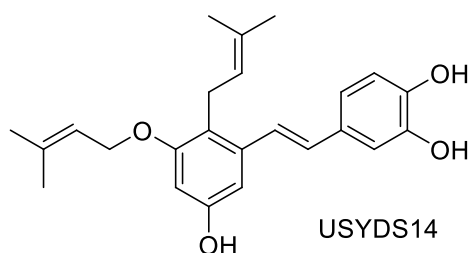
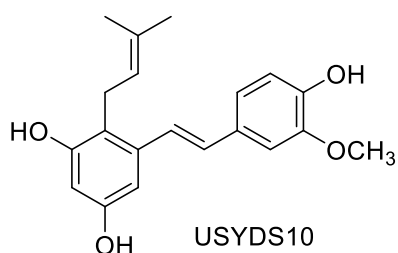
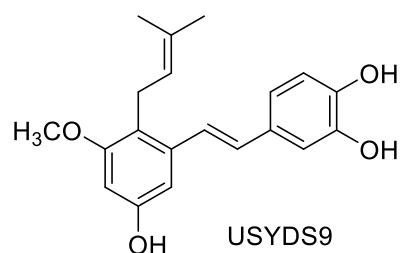
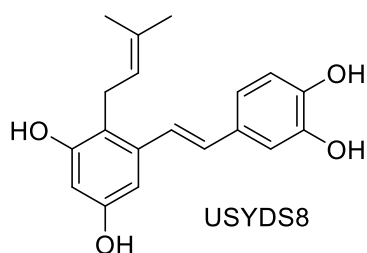
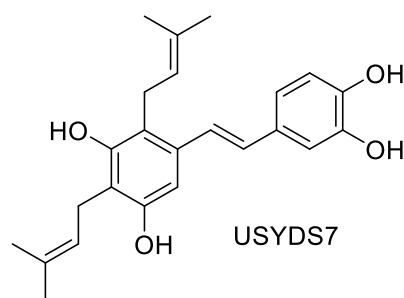
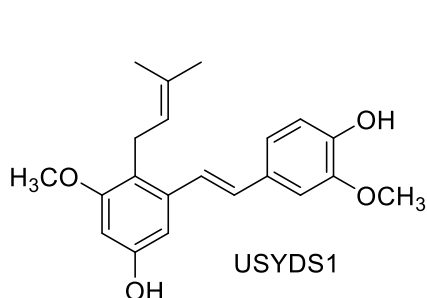
R^4 is selected from methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

and A----B is $\text{CH}=\text{CH}$;

in the preparation of a medicament for treating inflammation, bacterial infection and/or fungal infection.

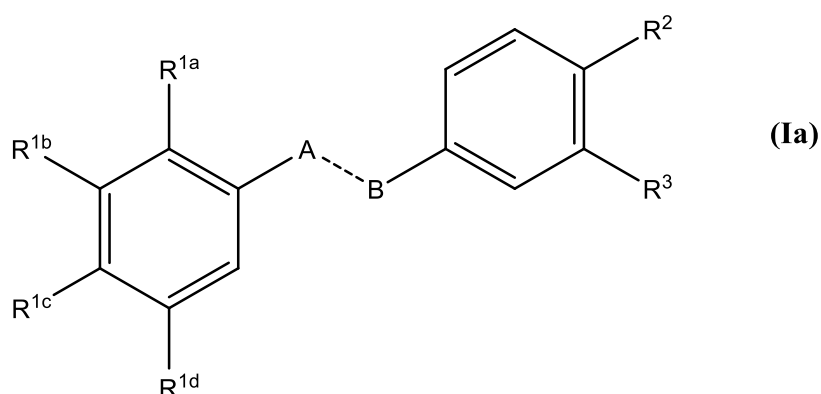
2. Use of a compound according to claim 1 wherein R^{1c} is H.
3. Use of a compound according to claim 1 or 2 wherein R^{1c} is $\text{CH}_2\text{CH}=\text{C}(\text{CH}_3)_2$.
4. Use of a compound according to any one of claims 1-3 wherein R^{1b} is $\text{OCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$.

5. Use of a compound according to any one of claims 1-3 wherein R^{1b} and R^{1d} are OH.
6. Use of a compound according to any one of claims 1-3 wherein R^{1b} is OR^4 and R^4 is methyl.
7. Use of a compound according to any one of claims 1-3 wherein at least one of R^2 or R^3 is OH.
8. Use of a compound according to any one of claims 1-3 wherein R^3 is OR^4 and R^4 is methyl.
9. Use of a compound according to any one of claims 1-3 wherein both R^2 and R^3 are OH.
- 10 Use of a compound selected from the group consisting of:



or pharmaceutically acceptable salt or solvate thereof,
in the preparation of a medicament for treating inflammation, bacterial infection and/or fungal infection.

11. Use of a compound of formula (Ia),



or a pharmaceutically acceptable salt, solvate, or pharmaceutical composition including said compound,

wherein:

R^{1a} is H;

R^{1b} is $\text{OCH}_2\text{CH}=\text{C}(\text{CH}_3)_2$;

R^{1c} is H;

R^{1d} is OH;

R^2 is OH or OR^4 ;

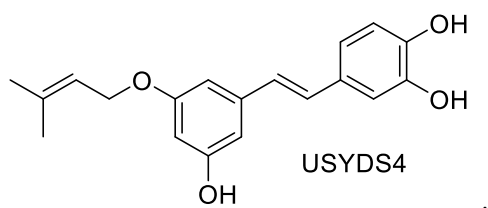
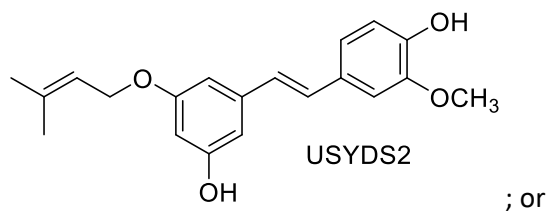
R^3 is OH or OR^4 ;

R^4 is selected from methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl or benzyl;

and A---B is $\text{CH}=\text{CH}$;

in the preparation of a medicament for treating inflammation, bacterial infection and/or fungal infection.

12. Use according to claim 11 wherein the compound is selected from the group consisting of:



in the preparation of a medicament for treating inflammation, bacterial infection and/or fungal infection.