[CLAIMS]

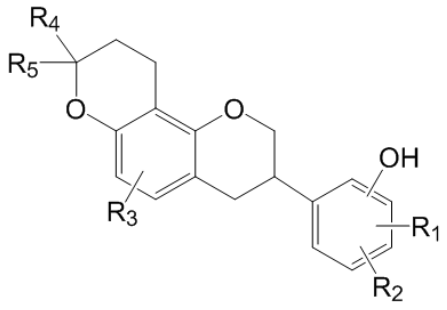
[Claim 1]

A method for synthesizing a 3-phenyl-2,3,4,8,9,10-hexahydropyrano[2,3-*f*]chromene derivative of Chemical Formula (I), the method comprising:

a) coupling a Compound represented by Chemical Formula 1 with a Compound represented by Chemical Formula 2 to form a Compound of Chemical Formula 3;

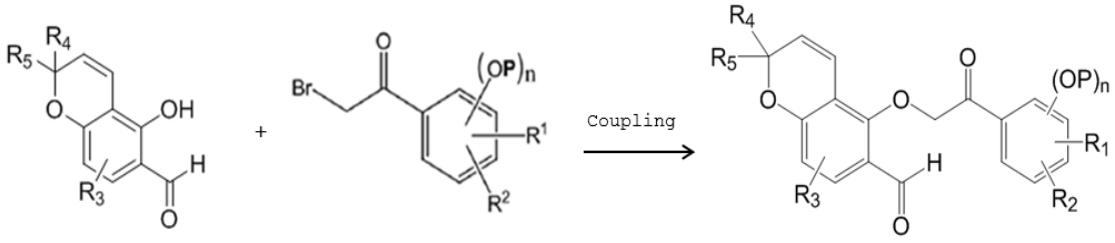
b) reducing the Compound of Chemical Formula 3 to form a Compound of Chemical Formula 4; and

c) cyclizing the Compound of Chemical Formula 4 to form a Compound of Chemical Formula 5:

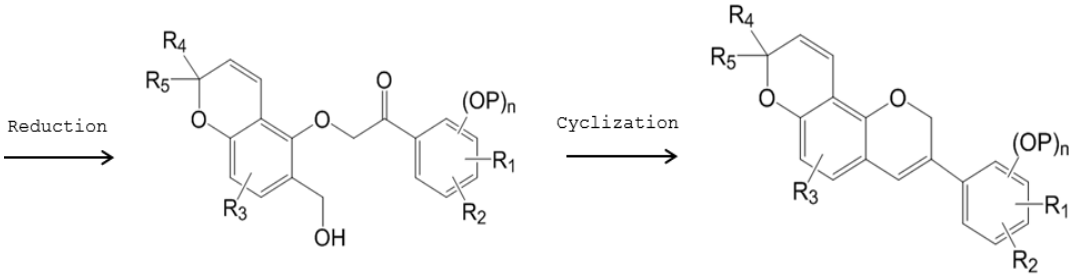


(I)

[Reaction Formula 1]



Chemical Formula 1 Chemical Formula 2 Chemical Formula 3



Chemical Formula 4 Chemical Formula 5

wherein,

R_1 and R_2 are each independently hydrogen atom; hydroxy group; straight or branched C_1 to C_6 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; halogen atom; straight or branched C_1 to C_6 alkoxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; straight or branched C_1 to C_4 thioalkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyloxy group unsubstituted or

substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; or aryloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group;

R_3 is hydrogen atom or C_1 to C_2 alkyl group or C_1 to C_2 alkoxy group;

R_4 and R_5 are each independently hydrogen atom or C_1 to C_6 alkyl group;

P is a protecting group selected from straight or branched C_1 to C_4 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; benzyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; tert-butyldimethylsilyl group; tert-butyldiphenylsilyl group; methylphenylsilyl group; trimethylphenylsilyl group; $MeSO_2$ and p-$TsSO_2$;

n is 1 to 3; and

two or more OPs are the same or different from each other.

[Claim 2]

The method of claim 1, further comprising:

reducing the Compound of Chemical Formula 5.

[Claim 3]

The method of claim 1, wherein the coupling in Step a) is performed under basic conditions.

[Claim 4]

The method of claim 3, wherein the basic conditions are created by adding one or more weak basic Compounds selected from a group consisting of sodium carbonate (Na_2CO_3), lithium carbonate (Li_2CO_3), potassium carbonate (K_2CO_3), sodium hydrogen carbonate ($NaHCO_3$), potassium hydrogen carbonate ($KHCO_3$), triethylamine, and pyridine.

[Claim 5]

The method of claim 1, wherein the reducing in Step b) is carried out by adding any one or more reducing agents selected from a group consisting of L-Selectride, N-Selectride, K-Selectride, and LS-Selectride.

[Claim 6]

The method of claim 5, wherein the reducing agent is added at -10°C or less.

[Claim 7]

The method of claim 1, wherein the cyclizing in Step c) includes the following steps:

i) dissolving the Compound of Chemical Formula 4 in acetonitrile and adding triphenylphosphonium bromide ($Ph_3P \cdot HBr$) thereinto;

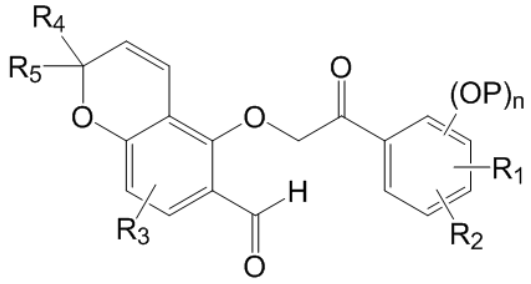
ii) concentrating the resulting product in Step i); and

iii) dissolving the concentrate obtained in Step ii) and adding sodium ethoxide (NaOEt) thereinto.

[Claim 8]

A Compound represented by the following Chemical Formula 3, or a solvate thereof:

[Chemical Formula 3]



wherein,

R_1 and R_2 are each independently hydrogen atom; hydroxy group; straight or branched C_1 to C_6 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; halogen atom; straight or branched C_1 to C_6 alkoxy

group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; straight or branched C_1 to C_4 thioalkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; or aryloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group;

R_3 is hydrogen atom or C_1 to C_2 alkyl group or C_1 to C_2 alkoxy group;

R_4 and R_5 are each independently hydrogen atom or C_1 to C_6 alkyl group;

P is a protecting group selected from straight or branched C_1 to C_4 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; benzyl group unsubstituted or substituted with halogen atom, straight or

branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; tert-butyldimethylsilyl group; tert-butyldiphenylsilyl group; methylphenylsilyl group; trimethylphenylsilyl group; $MeSO_2$ and p-$TsSO_2$;

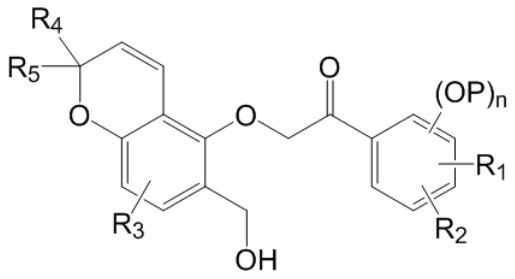
n is 1 to 3; and

two or more OPs are the same or different from each other.

[Claim 9]

A Compound represented by the following Chemical Formula 4, or a solvate thereof:

[Chemical Formula 4]



wherein,

R_1 and R_2 are each independently hydrogen atom; hydroxy group; straight or branched C_1 to C_6 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5

alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; halogen atom; straight or branched C_1 to C_6 alkoxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; straight or branched C_1 to C_4 thioalkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; or aryloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group;

R_3 is hydrogen atom or C_1 to C_2 alkyl group or C_1 to C_2 alkoxy group;

R_4 and R_5 are each independently hydrogen atom or C_1 to C_6 alkyl group;

P is a protecting group selected from straight or branched C_1 to C_4 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or

straight or branched C_1 to C_3 thioalkyl group; benzyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; tert-butyldimethylsilyl group; tert-butyldiphenylsilyl group; methylphenylsilyl group; trimethylphenylsilyl group; $MeSO_2$ and p-$TsSO_2$;

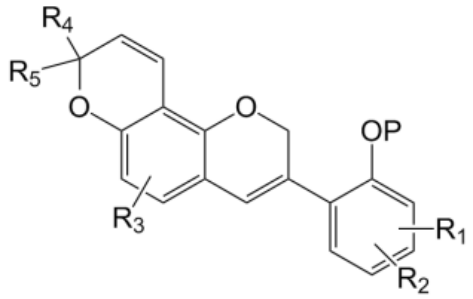
n is 1 to 3; and

two or more OPs are the same or different from each other.

[Claim 10]

A 3-phenyl-2,8-dihydropyrano[2,3-f]chromene Compound represented by the following Chemical Formula 5-1, or a solvate thereof:

[Chemical Formula 5-1]



wherein,

R_1 and R_2 are each independently hydrogen atom;

hydroxy group; straight or branched C_1 to C_6 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; halogen atom; straight or branched C_1 to C_6 alkoxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; straight or branched C_1 to C_4 thioalkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; or aryloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group;

R_3 is hydrogen atom or C_1 to C_2 alkyl group or C_1 to C_2 alkoxy group;

R_4 and R_5 are each independently hydrogen atom or C_1 to C_6 alkyl group;

P is a protecting group selected from benzyl group

unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; tert-butyldimethylsilyl group; tert-butyldiphenylsilyl group; methylphenylsilyl group; trimethylphenylsilyl group; $MeSO_2$ and p-$TsSO_2$.

[Claim 11]

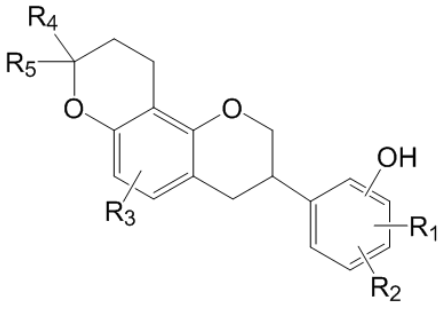
A method for synthesizing an optical isomer of a 3-phenyl-2,3,4,8,9,10-hexahydropyrano[2,3-*f*]chromene derivative of Chemical Formula (I), the method comprising:

A) coupling a Compound represented by Chemical Formula 1 with a Compound represented by Chemical Formula 2 to form a Compound of Chemical Formula 3;

B) reducing the Compound of Chemical Formula 3 to form a Compound of Chemical Formula 4;

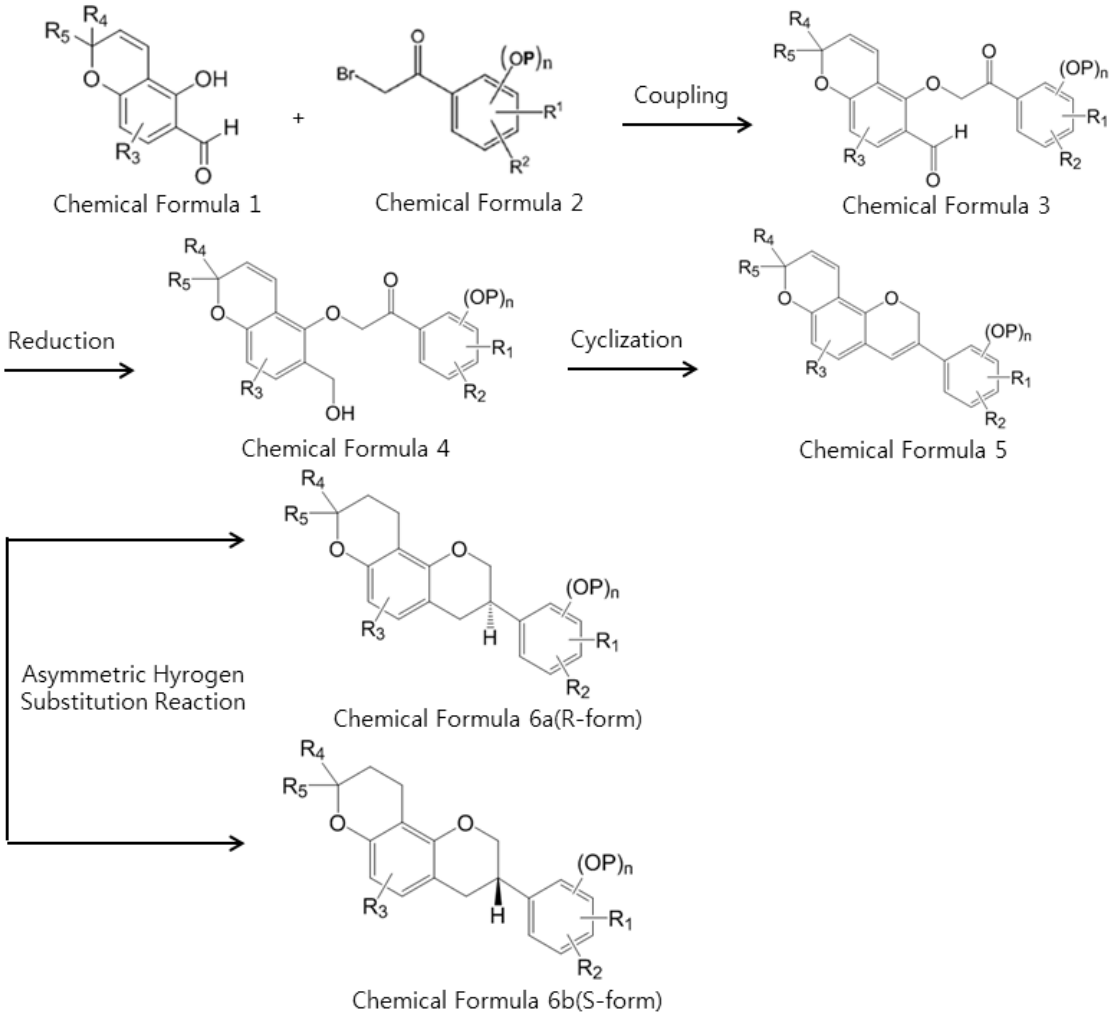
C) cyclizing the Compound of Chemical Formula 4 to form a Compound of Chemical Formula 5; and

D) subjecting the Compound represented by Chemical Formula 5 to an asymmetric hydrogenation reaction to form an optical isomer Compound of Chemical Formula 6a (R-form) or 6b (S-form):



(I)

[Reaction Formula 2]



wherein,

R_1 and R_2 are each independently hydrogen atom; hydroxy group; straight or branched C_1 to C_6 alkyl group unsubstituted or substituted with halogen atom, straight or

branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; halogen atom; straight or branched C_1 to C_6 alkoxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; straight or branched C_1 to C_4 thioalkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; or aryloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group;

R_3 is hydrogen atom or C_1 to C_2 alkyl group or C_1 to C_2 alkoxy group;

R_4 and R_5 are each independently hydrogen atom or C_1 to C_6 alkyl group;

P is a protecting group selected from straight or branched C_1 to C_4 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl

group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; benzyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; tert-butyldimethylsilyl group; tert-butyldiphenylsilyl group; methylphenylsilyl group; trimethylphenylsilyl group; $MeSO_2$ and p-$TsSO_2$;

n is 1 to 3; and

two or more OPs are the same or different from each other.

[Claim 12]

The method of claim 11, wherein the coupling in Step A) is performed under basic conditions.

[Claim 13]

The method of claim 12, wherein the basic conditions are created by adding one or more weak basic Compounds selected from a group consisting of sodium carbonate (Na_2CO_3), lithium carbonate (Li_2CO_3), potassium carbonate (K_2CO_3), sodium hydrogen carbonate ($NaHCO_3$), potassium hydrogen carbonate ($KHCO_3$), triethylamine, and pyridine.

[Claim 14]

The method of claim 11, wherein the reducing in Step B) is carried out by adding any one or more reducing agents selected from a group consisting of L-Selectride, N-Selectride, K-Selectride, and LS-Selectride.

[Claim 15]

The method of claim 14, wherein the reducing agent is added at -10°C or less.

[Claim 16]

The method of claim 11, wherein the cyclization reaction in Step C) includes the following steps:

i) dissolving the Compound of Chemical Formula 4 in acetonitrile and adding triphenylphosphonium bromide ($Ph_3P \cdot HBr$) thereinto;

ii) concentrating the resulting product in Step i); and

iii) dissolving the concentrate obtained in Step ii) and adding sodium ethoxide (NaOEt) thereinto.

[Claim 17]

The method of claim 11, wherein the asymmetric hydrogenation reaction in Step D) is a reaction caused by adding a chiral ligand.

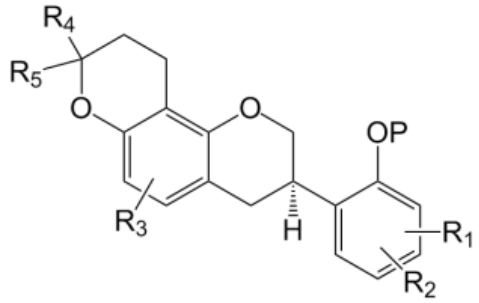
[Claim 18]

The method of claim 17, wherein the chiral ligand is any one selected from the group consisting of a phospholane ligand, a SimplePHOX ligand, a PHOX ligand, and UbaPHOX.

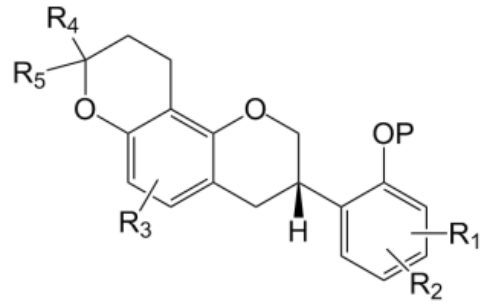
[Claim 19]

An optical isomer Compound represented by the following Chemical Formula 6a-1 (R-form) or 6b-1 (S-form), or a solvate thereof:

[Chemical Formula 6a-1]



[Chemical Formula 6b-1]



wherein,

R_1 and R_2 are each independently hydrogen atom; hydroxy group; straight or branched C_1 to C_6 alkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; halogen atom; straight or branched C_1 to C_6 alkoxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or

branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; straight or branched C_1 to C_4 thioalkyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; or aryloxy group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group;

R_3 is hydrogen atom or C_1 to C_2 alkyl group or C_1 to C_2 alkoxy group;

R_4 and R_5 are each independently hydrogen atom or C_1 to C_6 alkyl group;

P is a protecting group selected from benzyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; allyl group unsubstituted or substituted with halogen atom, straight or branched C_1 to C_5 alkyl group, straight or branched C_1 to C_5 alkoxy group, or straight or branched C_1 to C_3 thioalkyl group; tert-butyldimethylsilyl

group; tert-butyldiphenylsilyl group; methylphenylsilyl group; trimethylphenylsilyl group; $MeSO_2$ and $p\text{-}TsSO_2$.