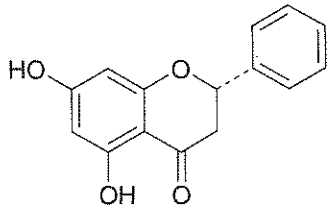
Two types of crystalline of pinocembrin, their preparation and their use for manufacture of pharmaceutical compositions

FIELD OF INVENTION

[01] The present invention relates to two crystalline forms of the compound pinocembrin, and active pharmaceutical ingredients, pharmaceutical compositions and dosage forms containing the two crystalline forms of pinocembrin, and the use thereof for manufacture of pharmaceutical compositions and treating diseases, and the method for preparing the two crystalline forms of pinocembrin.

BACKGROUND OF THE INVENTION

[02] Pinocembrin (chemical name: 5,7-dihydroxy-2-phenyl-4-chromanone) is a flavone compound, widely found in the nature. Its chemical structure is as below:



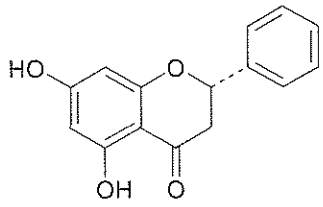
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exiting in l-isomer, d-isomer, l-isomer- or d-isomer-enriched mixture, and racemate.

[03] Previous pharmacological experiments showed that pinocembrin had strong bacteriostasis, antivirus, and antifungal activities. For example, honey, a Chinese traditional health care food, is rich in pinocembrin. So eating honey sugar frequently is not only harmless to the teeth, but also can sterilize the oral cavity, for example, relieving oral ulcer and accelerating wound healing. Chinese Patent CN1695608A, titled "Use of pinocembrin for manufacture of pharmaceutical compositions for preventing and treating diseases related to nerve cell injury"[1], disclosed the use of pinocembrin for manufacture of pharmaceutical compositions for preventing or treating diseases related to cerebral ischemia, sequelae of cerebral ischemia, nerve cell injury and function alteration.

SUMMARY OF THE INVENTION

[03a] In one aspect of the present invention, there is provided a β crystalline form of pinocembrin of formula (I):



(I)

characterized in that, when analyzed by X-ray powder (polycrystal) diffraction (CuK_α radiation), the diffraction peak locations: 2-Theta value (°) or d value (Å), and the relative strength of diffraction peak: peak height value (Height%) or peak area value (Area%), show the following characteristics:

Peak	2-Theta	d(Å)	Height%	Area%	Peak	2-Theta	d(Å)	Height%	Area%
1	7.33	12.06	100.0	66.5	14	29.51	3.02	1.6	0.3
2	9.41	9.40	6.2	4.9	15	31.03	2.88	0.7	0.4
3	11.33	7.81	6.1	4.5	16	34.47	2.60	1.0	1.5
4	14.07	6.29	2.9	2.2	17	35.45	2.53	0.4	0.2
5	14.69	6.03	27.2	17.6	18	37.24	2.41	1.5	0.7
6	17.49	5.07	63.9	100.0	19	38.15	2.36	1.2	0.9
7	19.01	4.67	2.8	1.5	20	40.61	2.22	3.1	2.8
8	21.49	4.13	0.1	0	21	42.83	2.11	1.5	1.4
9	22.11	4.02	12.9	11.2	22	44.89	2.02	1.6	1.3
10	23.17	3.84	19.4	9.5	23	46.01	1.97	2.4	1.8
11	25.91	3.44	3.3	2.5	24	50.36	1.81	0.7	0.8
12	27.41	3.25	31.7	27.4	25	56.63	1.62	1.0	0.9
13	28.31	3.15	19.0	15.1					

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[03b] In another aspect of the present invention, there is provided a mixed crystalline form of pinocembrin consisting of the β crystalline form of pinocembrin in any proportion as defined herein and α crystalline form of pinocembrin, when analyzed by X-ray single crystal diffraction, the α crystalline form shows monoclinic crystal system symmetry, the space group is $P2_1/c$, and the crystal cell parameter values are as follows: a=5.189Å, b=24.149Å, c=10.472Å, α=90°, β=102.31° and γ=90°.

[03c] In yet another aspect of the present invention, there is provided an active pharmaceutical ingredient, comprising the crystalline form of pinocembrin as defined herein as active ingredient, for use in the manufacture of a medicament for treating cerebral ischemia or for preventing cerebral ischemia by protecting neurovascular unit function.

[03d] In yet another aspect of the present invention, there is provided a pharmaceutical composition, comprising therapeutically effective amount of crystalline form of pinocembrin as defined herein, in combination with one or more pharmaceutically acceptable carriers.

[03e] In yet another aspect of the present invention, there is provided a dosage form, comprising the active pharmaceutical ingredient as defined herein, or the composition as defined herein, characterized in that the dosage form is tablet, capsule, pill, injection, sustained-release preparation or controlled-release preparation.

[03f] In yet another aspect of the present invention, there is provided a method for preparing β crystalline form of pinocembrin, as defined herein, comprising the steps of:

using α crystal form of pinocembrin as material, then

obtaining β crystalline form of pinocembrin through

(a) crystal transition by grinding, or

(b) dissolving the material completely in a solvent of pyridine or DMSO, adding water to allow precipitate, and performing filtration under reduced pressure, freeze-drying or cold spray,

wherein when analyzed by X-ray single crystal diffraction, the α crystal form shows monoclinic crystal system symmetry, the space group is $P2_1/c$, and the crystal cell parameter values are as follows: a=5.189Å, b=24.149Å, c=10.472Å, α=90°, β=102.31° and γ=90°.

DESCRIPTION OF THE INVENTION

[04] It was found surprisingly by the inventors that pinocembrin had two different crystalline forms α and β, and the inventors developed the preparations thereof. The inventors also found that there was a significant difference between the two crystalline forms in the uptake by organism, wherein the uptake rate of β crystalline form was greater than that of α crystalline form, for example, the uptake rate of β crystalline form can be 2 times or more greater than that of α crystalline from. The biological activities thereof in medicament therapy are different due to differences in drug blood concentrations.

[05] One embodiment of the present invention provides α crystalline form, β

crystalline form, or the mixture of α crystalline form and β crystalline form in different proportions, with respect to pinocembrin. Preferably, these crystalline forms or the mixture thereof contains no crystal water or other organic solvents.

[06] One embodiment of the present invention provides the method for preparing α crystalline form, β crystalline form, or the mixture of α crystalline form and β crystalline form of pinocembrin in different proportions.

[07] One embodiment of the present invention provides a pharmaceutical composition comprising pure α crystalline form, pure β crystalline form, or the mixture of α crystalline form and β crystalline form of pinocembrin in different proportions. The pharmaceutical composition can also comprise one or more pharmaceutically acceptable carriers. There is no limitation on the pharmaceutically acceptable carriers, provided that they are suitable for formulation and would not substantially affect the effect of pinocembrin crystalline form of the present invention.

[08] One embodiment of the present invention relates to dosage forms comprising the pinocembrin crystalline forms solid. There are no limitations on specific dosage forms. For example, they can be tablets, capsules, pills, injections, sustained-release preparations, controlled-release preparations and the like.

[09] One embodiment of the present invention provides use of the crystalline forms solid of pinocembrin, including α crystalline form, β crystalline form or the mixture of α crystalline form and β crystalline from in differerit proporations, for bringing about difference of drug uptake in treatment.

[10] One embodiment of the present invention relates to the use of α crystalline form, β crystalline form, or the mixture of α crystalline form and β crystalline form of pinocembrin in different proportions in the manufacture of a medicament for treating diseases related to cerebral ischemia or a medicament for preventing diseases related to cerebral ischemia by protecting neurovascular unit function.

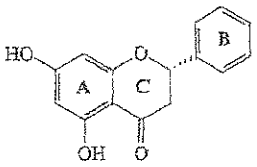
[11] One embodiment of the present invention provides the use of pinocembrin for protecting neurovascular unit function in the treatment of diseases related to cerebral ischemia, and for improving the blood concentration in an organism due to the crystal form effect.

Morphologic features of a sample of α crystalline form of pinocembrin according to an embodiment:

[12] For a sample of α crystalline form of pinocembrin obtained according to an embodiment of the present invention, when analyzed by X-ray single crystal diffraction, it showed monoclinic crystal system symmetry, the space group was $P2_1/c$, and the crystal cell parameter values were as follows: a=5.189Å, b=24.149Å, c=10.472Å, α=90°, β=102.31° and γ=90°.

Fig. 1 is an illustration showing the relative configuration of the molecule, Fig. 2 is an illustration showing the stereo-structure projection of the molecule, Fig. 3 is an illustration showing the unit cell stacking of the molecule along the a axis. Table 1

shows atomic coordinate parameters and equivalent temperature factors. Table 2 shows bond length values of bonding atoms. Table 3 shows bond angle values of bonding atoms. As some carbon atoms of B ring adopt a disordered orientation state, the four atoms of $C_{2'}$, $C_{3'}$, $C_{5'}$ and $C_{6'}$ occupy two positions, with an occupancy rate of 0.5 respectively.



Formula 1 relative molecule configuration of α crystalline form of pinocembrin

Table 1 Atomic coordinate parameters (relative coordinate) of a sample of α crystalline form of pinocembrin

	x	y	z	temperature factors	occupancy
O 1	-.2023(8)	-.6574(2)	-.7376(4)	3.4(2)	1.0
O 2	-.4261(9)	-.8310(2)	-.5601(4)	4.3(2)	1.0
O 3	-.8660(9)	-.6732(2)	-.3557(4)	4.2(2)	1.0
O 4	-.6128(8)	-.7370(2)	-.4969(4)	3.6(2)	1.0
C 2	-.4094(24)	-.6318(3)	-.6954(12)	3.5(8)	1.0
C 3	-.5019(13)	-.6513(3)	-.5885(6)	3.6(3)	1.0
C 4	-.4859(12)	-.7131(3)	-.5720(6)	3.0(3)	1.0
C10	-.3269(12)	-.7427(2)	-.6435(6)	2.8(3)	1.0
C 5	-.2968(12)	-.8009(2)	-.6366(6)	3.1(3)	1.0
C 6	-.1407(13)	-.8289(2)	-.7054(6)	3.3(3)	1.0
C 7	-.0117(12)	-.7979(2)	-.7862(6)	3.1(3)	1.0
C 8	-.0336(12)	-.7405(2)	-.7966(6)	2.8(3)	1.0
C 9	-.1894(12)	-.7138(2)	-.7262(6)	2.9(3)	1.0
C 1'	-.4049(18)	-.5701(3)	-.7176(9)	6.7(5)	1.0
C 2'	-.316 (5)	-.5292(7)	-.6099(19)	7.4(2)	0.5
C 3'	-.326 (5)	-.4730(7)	-.6436(21)	7.4(1)	0.5
C 4'	-.3988(18)	-.4566(3)	-.7567(10)	7.5(1)	1.0
C 5'	-.456 (5)	-.4929(8)	-.8580(22)	7.9(2)	0.5
C 6'	-.435 (6)	-.5510(7)	-.8288(23)	7.8(2)	0.5
C 2"	-.194 (4)	-.5453(7)	-.6870(25)	7.1(1)	0.5
C 3"	-.178 (4)	-.4859(7)	-.700 (3)	7.3(2)	0.5
C 5"	-.630 (4)	-.4859(7)	-.7856(22)	7.4(1)	0.5
C 6"	-.640 (4)	-.5432(6)	-.7752(22)	8.8(1)	0.5
H 2	-.591	-.644	-.779	7.6	1.0
H 3A	-.701	-.637	-.587	5.0	1.0
H 3B	-.369	-.632	-.502	5.0	1.0
H 6	-.116	-.874	-.697	4.3	1.0
H 8	.070	-.717	-.861	3.6	1.0
HO 2	-.525	-.802	-.507	3.2	1.0

HO 3	-.775	-.699	-.420	3.2	1.0
H 2'	-.177	-.548	-.528	3.2	0.5
H 3'	-.160	-.447	-.578	3.2	0.5
H 4'	-.430	-.413	-.771	3.2	1.0
H 5'	-.591	-.477	-.952	3.2	0.5
H 6'	-.533	-.577	-.908	3.2	0.5
H 2"	-.095	-.557	-.569	3.2	0.5
H 3"	-.072	-.456	-.601	3.2	0.5
H 5"	-.723	-.469	-.896	3.2	0.5
H 6"	-.742	-.570	-.857	3.2	0.5

Table 2 Bond length values of bonding atoms of a sample of α crystalline form of pinocembrin (Å)

Bonding Atoms	Bond Length	Bonding Atoms	Bond Length
O(1)-C(2)	1.391(9)	C(6)-C(7)	1.402(8)
O(1)-C(9)	1.369(7)	C(6)-H(6)	1.098(16)
O(2)-C(5)	1.360(7)	C(7)-O(3)	1.351(7)
O(2)-Ho(2)	1.090(20)	C(7)-C(8)	1.393(8)
O(3)-C(7)	1.351(7)	C(8)-C(9)	1.366(8)
O(3)-Ho(3)	1.100(21)	C(8)-H(8)	1.099(23)
O(4)-C(4)	1.268(7)	C(1')-C(2')	1.497(22)
C(2)-C(3)	1.391(11)	C(1')-C(6')	1.230(30)
C(2)-C(1')	1.509(10)	C(2')-C(3')	1.399(25)
C(2)-H(2)	1.183(24)	C(2')-H(2')	1.090(30)
C(3)-C(4)	1.503(8)	C(3')-C(4')	1.229(24)
C(3)-H(3A)	1.087(21)	C(3')-H(3')	1.160(30)
C(3)-H(3B)	1.109(21)	C(4')-C(5')	1.360(30)
C(4)-C(10)	1.420(8)	C(4')-H(4')	1.072(17)
C(10)-C(5)	1.416(8)	C(5')-C(6')	1.430(3)
C(10)-C(9)	1.417(8)	C(5')-H(5')	1.150(3)
C(5)-C(6)	1.371(8)	C(6')-H(6')	1.080(3)

Table 3 Bond angle values of bonding atoms of a sample of α crystalline form of pinocembrin (°)

Bonding atoms	Bond angle value	Bonding atoms	Bond angle value
C(2)-O(1)-C(9)	116.2(5)	C(5)-C(6)-H(6)	121.2(13)
C(5)-O(2)-Ho(2)	107.8(11)	C(7)-C(6)-H(6)	121.1(13)
C(7)-O(3)-Ho(3)	113.3(11)	O(3)-C(7)-C(6)	116.2(5)
C(4)-O(4)-Ho(2)	102.1(9)	O(3)-C(7)-C(8)	121.3(5)
C(4)-O(4)-Ho(3)	117.2(8)	C(6)-C(7)-C(8)	122.5(5)
O(1)-C(2)-C(3)	121.9(7)	C(7)-C(8)-C(9)	118.3(5)
O(1)-C(2)-C(1')	110.5(6)	C(7)-C(8)-H(8)	120.8(10)
O(1)-C(2)-H(2)	101.5(12)	C(9)-C(8)-H(8)	120.9(10)
C(3)-C(2)-C(1')	118.5(7)	O(1)-C(9)-C(10)	121.4(5)

C(3)-C(2)-H(2)	99.1(13)	O(1)-C(9)-C(8)	116.5(5)
C(1')-C(2)-H(2)	99.8(11)	C(10)-C(9)-C(8)	122.1(5)
C(2)-C(3)-C(4)	114.0(6)	C(2)-C(1')-C(2')	123.3(10)
C(2)-C(3)-H(3A)	113.3(13)	C(2)-C(1')-C(6')	120.9(11)
C(2)-C(3)-H(3B)	104.8(14)	C(1')-C(2')-C(3')	117.4(16)
C(4)-C(3)-H(3A)	109.6(10)	C(1')-C(2')-H(2')	111.2(16)
C(4)-C(3)-H(3B)	107.7(10)	C(2')-C(3')-C(4')	122.9(16)
H(3A)-C(3)-H(3B)	106.9(15)	C(2')-C(3')-H(3')	113.0(20)
O(4)-C(4)-C(3)	120.1(5)	C(4')-C(3')-H(3')	115.5(20)
O(4)-C(4)-C(10)	122.2(5)	C(3')-C(4')-C(5')	121.0(13)
C(3)-C(4)-C(10)	117.6(5)	C(3')-C(4')-H(4')	117.3(16)
C(4)-C(10)-C(5)	123.0(5)	C(5')-C(4')-H(4')	121.5(16)
C(4)-C(10)-C(9)	120.0(5)	C(4')-C(5')-C(6')	118.0(18)
C(5)-C(10)-C(9)	117.0(5)	C(4')-C(5')-H(5')	116.5(18)
O(2)-C(5)-C(10)	119.8(5)	C(6')-C(5')-H(5')	120.9(24)
O(2)-C(5)-C(6)	117.9(5)	C(1')-C(6')-C(5')	123.9(17)
C(10)-C(5)-C(6)	122.3(5)	C(1')-C(6')-H(6')	117.0(19)
C(5)-C(6)-C(7)	117.8(5)	C(5')-C(6')-H(6')	113.9(25)

Note: in table 2 and 3, for the atoms $C_{2'}$, $C_{3'}$, $C_{5'}$ and $C_{6'}$ of B ring, only the bond length and bond angle values of one position are given in Table 2 and 3.

[13] Powder (polycrystal) X-ray diffraction (CuK_α radiation) was performed on the α crystalline form solid of pinocembrin, and the diffraction peak locations: 2-Theta value (°) or d value (Å), and the relative strength of diffraction peak: peak height value (Height%) or peak area value（Area%） show the following characteristics (see Table 4, Fig. 4).

Table 4 characteristic peak values of powder X-ray diffraction for a sample of α crystalline form of pinocembrin

Peak	2-Theta	d(Å)	Height%	Area%	Peak	2-Theta	d(Å)	Height%	Area%
1	7.32	12.07	100.0	100.0	17	27.30	3.26	7.2	9.6
2	9.37	9.44	2.3	2.5	18	27.51	3.24	7.1	14.1
3	11.30	7.82	2.1	2.2	19	28.29	3.15	5.7	6.4
4	13.93	6.35	1.5	2.5	20	29.53	3.02	1.7	1.9
5	14.65	6.04	27.3	27.1	21	30.88	2.89	0.8	1.0
6	17.04	5.20	5.5	8.7	22	34.51	2.60	1.2	1.2
7	17.31	5.12	11.8	18.2	23	35.37	2.54	0.5	0.6
8	17.80	4.98	5.6	26.6	24	37.21	2.41	2.4	2.4
9	18.16	4.88	2.2	1.8	25	38.27	2.35	0.8	1.4
10	18.83	4.71	1.6	2.1	26	40.53	2.22	0.5	0.8
11	21.47	4.13	0.9	0.5	27	41.40	2.18	0.3	0.3
12	22.06	4.03	12.5	13.8	28	42.09	2.15	1.1	1.1
13	22.40	3.97	2.2	2.4	29	45.96	1.97	2.8	3.2
14	23.09	3.85	2.6	2.0	30	46.67	1.94	0.5	0.7
15	23.74	3.74	1.8	1.6	31	56.49	1.63	0.3	0.5
16	25.83	3.45	1.5	1.8					

[14]In an embodiment of the present invention, when analyzed by DSC, α crystalline form solid of pinocembrin shows a decalescence transition temperature of about 206℃(see Fig. 5).

[15]IR analysis with KBr pellet was performed on α crystalline form solid of pinocembrin (see Fig. 6).The characteristic peaks were as follows: 3090.6, 3011.6, 2889.1, 2747.4, 2636.2, 1631.5, 1602.5, 1584.3, 1487.7, 1466.2, 1454.5, 1435.6, 1354.9, 1302.4, 1257.0, 1217.0, 1168.2, 1088.6, 1064.9, 1028.0, 1014.6, 1001.3, 975.8, 918.0, 887.7, 861.8, 825.9, 789.9, 766.4, 715.2, 698.1, 663.7, 646.7, 620.3, 587.3, 574.9, 560.5, 526.9 and 487.9cm^{-1}, wherein the peaks of 2891.1, 2747.4, 2636.2, 1631.5 and 1354.9 cm^{-1} were the main characteristic peaks of α crystalline form solid of pinocembrin.

Morphologic features of a sample of β crystalline form of pinocembrin according to an embodiment:

[16]For β crystalline form of pinocembrin obtained according to an embodiment of the present invention, when analyzed by powder (polycrystal) X-ray diffraction (CuK_α radiation), it showed the diffraction peak location:2-Theta value (°) or d value (Å) and the relative strength of diffraction peak: peak height value (Height%) or peak area value(Area%), shown as the following characteristic peak values (see Table 5, Fig. 7)

Table 5 characteristic peak values of powder X-ray diffraction for a sample of β crystalline form of pinocembrin

Peak	2-Theta	d(Å)	Height%	Area%	Peak	2-Theta	d(Å)	Height%	Area%
1	7.33	12.06	100.0	66.5	14	29.51	3.02	1.6	0.3
2	9.41	9.40	6.2	4.9	15	31.03	2.88	0.7	0.4
3	11.33	7.81	6.1	4.5	16	34.47	2.60	1.0	1.5
4	14.07	6.29	2.9	2.2	17	35.45	2.53	0.4	0.2
5	14.69	6.03	27.2	17.6	18	37.24	2.41	1.5	0.7
6	17.49	5.07	63.9	100.0	19	38.15	2.36	1.2	0.9
7	19.01	4.67	2.8	1.5	20	40.61	2.22	3.1	2.8
8	21.49	4.13	0.1	0	21	42.83	2.11	1.5	1.4
9	22.11	4.02	12.9	11.2	22	44.89	2.02	1.6	1.3
10	23.17	3.84	19.4	9.5	23	46.01	1.97	2.4	1.8
11	25.91	3.44	3.3	2.5	24	50.36	1.81	0.7	0.8
12	27.41	3.25	31.7	27.4	25	56.63	1.62	1.0	0.9
13	28.31	3.15	19.0	15.1					

[17]In an embodiment of the present invention, when analyzed by DSC, β crystalline form solid of pinocembrin shows a decalescence transition temperature of about 204℃(see Fig. 8).

[18]IR analysis with KBr pellet was performed on β crystalline form solid of pinocembrin according to an embodiment of the present invention (see Fig. 9).The characteristic peaks were as follows: 3090.8, 2890.0, 2748.9, 2638.3, 1633.5, 1602.9, 1585.0, 1487.9, 1466.1, 1454.3, 1344.4, 1302.7, 1216.7, 1168.2, 1088.4, 1065.5, 1028.8, 1014.3, 1001.5, 975.8, 917.8, 888.2, 861.8, 826.6, 789.1, 766.6, 741.1, 715.4,

698.0, 663.7, 646.0, 620.5, 587.9, 574.8, 560.9, 527.2 and 488.4cm^{-1}, wherein the peaks of 2890.0、2748.9、2638.3, 1633.5 and 1344.4 cm^{-1} were the main characteristic peaks of β crystalline form solid of pinocembrin.

Method for preparing a sample of α crystalline form of pinocembrin according to an embodiment of the present invention

[19](1) dissolving a sample completely in a solvent selected from the group consisting of methanol, ethanol, chloroform, acetone, ethyl acetate, n-butanol, isopropanol, acetonitrile, THF, dioxane, 95% ethanol, glacial acetic acid, formic acid, ether, dichloromethane, toluene, benzene, n-hexane, cyclohexane, dioxane, DMF, petroleum ether, ammonia, n-propanol, or a mixture thereof, then,

(a) placing the mixture in a condition of temperature 4-50 ℃ and relative humidity 10%-75% to allow recrystallization for 1 to 60 days, or

(b) adding water to allow precipitate, then obtaining α crystalline form of pinocembrin through filtration under reduced pressure, freeze-drying or cold spray.

Method for preparing a sample of β crystalline form of pinocembrin according to an embodiment of the present invention

[20] using a sample of α crystal form solid as the material, then

obtaining a sample of β crystalline form of pinocembrin through

(a) crystal transition by grinding, or

(b) dissolving the material completely in a solvent of pyridine or DMSO, adding water to allow precipitate, and performing filtration under reduced pressure, freeze-drying or cold spray.

Pharmacodynamics characteristics of pinocembrin sample:

[21] Pure α crystalline form, pure β crystalline form or the mixture of α and β crystalline forms of pinocembrin in any proportion according to the present invention have an effect on treating diseases related to cerebral ischemia or preventing diseases related to cerebral ischemia by protecting neurovascular unit function.

[22] There is a difference in bioavailability between pure α crystalline form and pure β crystalline form of present invention. For oral administration, the bioavailability of β crystalline form is more than 2 times higher than that of α crystalline form. For a mixture of the two crystalline forms in any proportion, the bioavailability thereof can vary, dependent on different contents of β crystalline form.

Dosage and preparation characteristics:

[23] For a pharmaceutical composition or a preparation comprising pure α crystalline form, pure β crystalline form or a mixture thereof in any proportion of pinocembrin

according to an embodiment of present invention, daily dosage is 5~250 mg, based on pinocembrin crystalline forms solid. Preparations include tablets, capsules, pills, injections, sustained-release preparations, controlled-release preparations and the like.

Brief Description of the Drawings

[24] Fig. 1 is an illustration showing the relative configuration of the molecule.

[25] Fig. 2 is an illustration showing the stereo-structure projection of the molecule.

[26] Fig. 3 is an illustration showing the unit cell stacking of the molecule (along the a axis).

[27] Fig. 4 is a powder X-ray diffraction pattern for a sample of α crystalline form of pinocembrin.

[28] Fig. 5 is a DSC trace for a sample of α crystalline form of pinocembrin.

[29] Fig. 6 is an infrared absorption spectra for a sample of α crystalline form of pinocembrin.

[30] Fig. 7 is a powder X-ray diffraction pattern for a sample of β crystalline form of pinocembrin.

[31] Fig. 8 is a DSC trace for a sample of β crystalline form of pinocembrin.

[32] Fig. 9 is an infrared absorption spectra for a sample of β crystalline form of pinocembrin.

Detailed Description of the Invention

[33] The following exemplary examples are provided for the purpose of better description of the present invention, however, it should be appreciated that the present invention is not limited to the given examples.

Instruments and test conditions for the following examples:

1. Monocrystal X-ray analysis

   Instrument: MAC DIP-2030K area detector

   Test condition: tube voltage: 50KV, tube flow: 80mA, ω scanning, MoK_α, $2\theta \leq 50.0°$, scan range: 0-180°, pivot angle: 6°, step: 6°, scan rate: 1.8°/min.

2. Powder X-ray analysis

   Instrument: Rigaku D/max 2550 powder X-ray diffractometer

   Test conditions: voltage: 40KV, current: 150mA, scan rate: 8°/min.

3. DSC analysis

   Instrument type: Seiko Instruments Inc. Differential Scanning Calorimeter

   Test conditions: purge gas: N_2, heating rate: 10℃/min.

   Temperature range: 25-250℃

4. IR absorbance spectra

Instrument Nicolet FT-IR spectrometer: IMPACT 400

Test conditions: KBr pellet

5. HPCL analysis

Instrument: SHIMADZU LC-10Avp high performance liquid chromatography, SPD-M10Avp diode array detector, CLASS-VP chromatography data system; column: Alltch C_{18}(5μ, 150×4.6mm); test conditions: column temperature: room temperature; wavelength: 290nm; mobile phase: methanol/phosphate saline pH 3.0 (64/36); flow rate : 1.0 mL/min; injection volume: 20μL; injection concentration: 500.0μg/mL.

Preparation 1: Synthesis of pinocembrin sample

[34] To 1000ml hydrogenation reaction kettle, was added 5g (19.7mmol) of 5,7-dihydroxyflavone, 650ml of anhydrous ethanol, and 1.5g of 10% palladium on carbon. Under a hydrogen pressure of 0.13Mpa, the reaction was performed for 4h at 40℃. When the reaction was finished, the palladium on carbon was filtered. The filtrate was concentrated, then separated and purified by column chromatography (eluted by methanol: acetic ether : petroleum ether = 2:10:100 (V:V:V)) under vacuum. The solvent was evaporated to dryness, and 3.9g of white amorphous solid powder was obtained (purity: 98.6%, detected by HPLC) in a yield of 52%[2].

Preparation of a sample of α crystalline form of pinocembrin

Example 1: Method 1 for preparing a sample of α crystalline form of pinocembrin

[35] 5g pinocembrin sample was added to 20ml of 95% ethanol, and was heated to be dissolved completely, then cooled to room temperature and allowed to stand for 24h. White solid was precipitated, and was filtered and dried. 4.5g of white crystalline (purity: 98.8%, detected by HPLC) was obtained in a recovery of 90%.

[36] The obtained crystalline was analyzed by X-ray single crystal diffraction. It showed monoclinic symmetry, space group was $P2_1/c$, and the crystal cell parameter values were a=5.189Å, b=24.149Å, c=10.472Å, α=90°, β=102.31° and γ=90°.

[37] Powder (polycrystal) X-ray diffraction (CuK_α radiation) was performed on the obtained crystalline. The characteristic peak values of the diffraction peak location: 2-Theta value (°) or d value (Å) and the relative strength of diffraction peak: peak height value (Height%) or peak area value (Area%) were shown in Table 4, and the obtained trace was shown in Fig. 4.

[38] DSC analysis was performed on the obtained crystalline, and decalescence transition temperature was 206℃.

[39] IR analysis with KBr pellet was performed on the crystalline obtained, and the

characteristic peaks were as follows: 3090.6, 3011.6, 2889.1, 2747.4, 2636.2, 1631.5, 1602.5, 1584.3, 1487.7, 1466.2, 1454.5, 1435.6, 1354.9, 1302.4, 1257.0, 1217.0, 1168.2, 1088.6, 1064.9, 1028.0, 1014.6, 1001.3, 975.8, 918.0, 887.7, 861.8, 825.9, 789.9, 766.4, 715.2, 698.1, 663.7, 646.7, 620.3, 587.3, 574.9, 560.5, 526.9 and 487.9cm^{-1}.

[40] The above spectra data showed that the crystalline form obtained in the present example was α crystalline form.

Examples 2 to 10: Methods 2 to 10 for preparing a sample of α crystalline form of pinocembrin

[41] Referring to the preparation method of Example 1, using ethyl acetate, chloroform, acetone, acetonitrile, THF, ether, benzene, cyclohexane or DMF as the solvent, white crystalline of pinocembrin was obtained. The results of the experiments were shown in table 6. Powder X-ray diffraction, DSC and IR analysis were performed on the obtained crystalline, and the results showed that the crystalline form was α crystalline form of pinocembrin.

Table 6 Results of the preparation of samples of α crystalline form of pinocembrin

example	reaction solvent	product weight (g)	HPLC purity (%)	recovery (%)
2	ethyl acetate	4.40	99.0	88
3	chloroform	4.30	98.7	86
4	acetone	4.30	99.1	86
5	acetonitrile	4.20	98.9	84
6	THF	4.25	98.8	85
7	ether	4.35	98.6	87
8	benzene	4.20	98.9	84
9	cyclohexane	4.20	98.6	84
10	DMF	4.20	98.7	84

Example 11: Method 11 for preparing the sample of α crystalline form of pinocembrin

[42] 5g pinocembrin sample was dissovled in 100ml mixture of 95% ethanol and acetone(95% ethanol : acetone=1:1) completely at room temperature, then 100ml water was added under stirring, and white precipitate appeared. The precipitate was filtered under reduced pressure and dried to obtain 4.00g white crystalline (purity: 98.7%) in a recovery of 80.0%. Powder X-ray diffraction, DSC and IR analysis were performed on the obtained crystalline form, and the results showed that the crystalline form obtained was α crystalline form of pinocembrin.

Examples 12 to 16

Methods 12 to 16 for preparing a sample of α crystalline form of pinocembrin

[43] Referring to the preparation method of Example 1, using the mixture of isopropanol and THF (isopropanol : THF=2:1), the mixture of acetonitrile and DMF (acetonitrile : DMF=4:1), the mixture of methanol and acetone (methanol : acetone=3:2), the mixture of ethanol and acetonitrile (ethanol : acetonitrile=1:1), and the mixture of ethanol, acetone and glacial acetic acid (ethanol:acetone:glacial acetic acid=2:1:0.1) as the solvents, white crystalline of pinocembrin was obtained. The results of the experiments were shown in Table 7. Powder X-ray diffraction, DSC and IR analysis were performed on the obtained crystalline, and the results showed that the crystalline form obtained was α crystalline form of pinocembrin.

Table 7 Results of samples of α crystalline form of pinocembrin

example	reaction solvent	product weight (g)	HPLC purity (%)	recovery (%)
12	2 : 1 isopropanol-THF	4.00	98.8	80
13	4 : 1 acetonitrile-DMF	3.80	98.7	76
14	3 : 2 methanol-acetone	3.90	98.9	78
15	1 : 1 ethanol-acetonitrile	4.05	99.0	81
16	2 : 1 : 0.1 ethanol-acetone-glacial acetic acid	4.10	98.9	82

Preparation of a sample of β crystalline form of pinocembrin

Example 17: Method 1 for preparing a sample of β crystalline form of pinocembrin:

[44] 10g sample of α crystalline form of pinocembrin was placed in a mortar, grinded evenly in the same direction for 1 hour at room temperature, and white crystalline was obtained, which is different from α crystalline form.

[45] Powder (polycrystal) X-ray diffraction (CuK_α radiation) was performed on the obtained crystalline. The characteristic peak values of the diffraction peak location:2-Theta value (°) or d value (Å) and the relative strength of diffraction peak: peak height value (Height%) or peak area value (Area%), were shown in Table 5, and the obtained trace was shown in Fig. 7.

[46] DSC analysis was performed on the obtained crystalline, and decalescence transition temperature was 204℃, as showed in the DSC trace.

[47] IR analysis with KBr pellet was performed on the crystalline obtained, and the characteristic peaks were as follows: 3090.8, 2890.0, 2748.9, 2638.3, 1633.5, 1602.9, 1585.0, 1487.9, 1466.1, 1454.3, 1344.4, 1302.7, 1216.7, 1168.2, 1088.4, 1065.5, 1028.8, 1014.3, 1001.5, 975.8, 917.8, 888.2, 861.8, 826.6, 789.1, 766.6, 741.1, 715.4, 698.0, 663.7, 646.0, 620.5, 587.9, 574.8, 560.9, 527.2 and 488.4cm^{-1}.

[48] The above spectra date showed that the crystalline form obtained in the present example was β crystalline form.

Example 18: Method 2 for preparing β crystalline form of pinocembrin

[49] At room temperature, 5g pinocembrin sample was dissolved in 75ml DMSO, then to which 150ml of water was added under stirring, and white precipitate appeared. The precipitate was filtered and dried to obtain 4.2g white crystalline (purity: 98.8%, detected by HPLC) in a recovery of 84.0%. Powder X-ray diffraction, DSC and IR analysis were performed on the obtained crystalline, and the results showed that the crystalline form obtained was β crystalline form of pinocembrin.

Example 19: Method 3 for preparing a sample of β crystalline form of pinocembrin

[50] Except that pyridine was used as the solvent, the same preparation method as that of Example 18 was used, and 8.8g white crystalline was obtained (purity: 98.6%, detected by HPLC) in a recovery of 88.0%. Powder X-ray diffraction, DSC and IR analysis were performed on the obtained crystalline, and the results showed that the crystalline form obtained was β crystalline form of pinocembrin.

Example 20

Method for preparing a sample of pinocembrin mixture of α crystalline form and β crystalline form in a ratio 1:1

[51] 10g of pinocembrin sample α and β crystalline form were respectively weighed and placed into a sealable vessel. The vessel was sealed and shook to mix the solid evenly. The mixture sample of α and β crystalline form in a ratio 1:1 was obtained.

Formulation

Example 21

Method 1 for preparing a combined pharmaceutical preparation (tablet)

[52] The samples of pure α crystalline form, pure β crystalline form, or solid mixture of (α+β) crystalline form (α:β=1:1) of pinocembrin were mixed with excipients in different proportions to obtain a solid of the combined pharmaceutical active ingredients. Tablets containing 5~60mg of active ingredients were prepared. The tablet formula were given in Table 8.

Table 8 Preparation formula for combined pinocembrin tablets

components	amount (g/1000 tablets)						
	Formula 1	Formula 2	Formula 3	Formula 4	Formula 5	Formula 6	Formula 7
Pinocembrin (g)	5.0	10.0	20.0	30.0	40.0	50.0	60.0
Lactose (g)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Starch (g)	35	30	20	10	—	—	—
Low-substituted hydroxypropyl cellulose (g)	3.0	3.0	3.0	3.0	3.0	3.0	3.0

MCC (g)	—	—	—	—	3.0	3.0	3.0
Talc powder (g)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Magnesium stearate (g)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1% Sodium hydroxymethyl cellulose	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

[53] The detailed preparation method was as follows: mixing the excipients with pinocembrin evenly, then adding appropriate amount of 1% sodium hydroxymethyl cellulose solution to make a dough. The dough was screened to obtain granules. The wet granules were dried and sieved. Then magnesium stearate and talc powder were added and mixed evenly, and the product was obtained by tabletting.

Example 22

Method 2 for preparing a combined pharmaceutical formulation (capsule)

[54] The samples of pure α crystalline form, pure β crystalline form, or solid mixture of (α+β) crystalline form (α:β=1:1 or 1:3) of pinocembrin were mixed with excipients in different proportions to obtain a solid of the combined pharmaceutical active ingredients. The capsules containing 5~60mg of active ingredients were prepared. The capsule formulas were given in Table 9.

Table 9 Preparation formulas for combined pinocembrin capsules

components	Amount (g/1000 capsules)						
	Formula 1	Formula 2	Formula 3	Formula 4	Formula 5	Formula 6	Formula 7
Pinocembrin (g)	5.0	10.0	20.0	30.0	40.0	50.0	60.0
Lactose(g)	—	—	—	—	—	—	—
Starch(g)	100.0	100.0	100.0	100.0	—	—	—
MCC(g)	-	-	-	-	70.0	60.0	50.0
Magnesium stearate(g)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1% Sodium hydroxymethyl cellulose	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

[55] The detailed preparation method was as follows: mixing the excipients with pinocembrin evenly, then appropriate amount of 1% sodium hydroxymethyl cellulose solution was added to make wet granules, the wet granules were dried and sieved. Then magnesium stearate was added and mixed evenly, and the product was obtained by filling the mixture above into empty capsules. Alternatively, without granulation, the product was obtained by filling the excipients and pinocembrin into empty

capsules directly, after they were mixed evenly and sieved.

Example 23

Method 3 for preparing combined pharmaceutical formulation (injection solution and freeze-dried powder for injection)

[56] Pure α crystalline form, pure β crystalline form, or solid mixture of (α+β) crystalline form (α:β=1:1) of pinocembrin were mixed with excipients in different proportions to obtain a solid of the combined pharmaceutical active ingredients. Then the injections containing 5~60mg of active ingredients per ampoule were obtained. The injection formulas were given in Table 10.

Table 10 Preparation formula for combined pinocembrin injections

components	Formula 1	Formula 2	Formula 3	Formula 4
Pinocembrin (g)	1	1	1	1
Hydroxypropyl-β-cyclodextrin (g)	40	40	20	20
Distilled water (ml)	400	100	10000	10000
Ethanol (ml)	20	20	20	20
Sodium chloride (g)			90	
Dextrose (g)				500

Formula 1: Preparation of pinocembrin injection solution

(1) To 400ml of distilled water, 40g of hydroxypropyl-β-cyclodextrin was added and dissolved with stirring;

(2) To 20ml ethanol, 1g of pinocembrin was added and dissolved, then the obtained solution was added into the hydroxypropyl-β-cyclodextrin solution mentioned above;

(3) The mixed solution was stirred magnetically for 20min at 40~50℃. When the solution became clear and transparent, 0.5g of actived carbon for injection was added. Then the mixture was heated to 80℃ with stirring and kept at this temperature for 15min, then the carbon was filtered. The filtrate was subpackaged into ampoule at 4 ml each. Pinocembrin injection solution was obtained after sterilizing at 121℃ for 15min.

Formula 2: Preparation of pinocembrin freeze-dried powder for injection

(1) In the sterile room, 40g of hydroxypropyl-β-cyclodextrin was weighed and dissolved in water to make 150ml solution. 0.1g actived carbon was added, and the mixture was heated to mild boiling for 15min, and then the carbon was filtered out;

(2) 1g of pinocembrin was dissolved in 20ml anhydrous ethanol, then the obtained solution was added into the hydroxypropyl-β-cyclodextrin solution mentioned above;

(3) The mixture was stirred magnetically for 20min at 40~50℃. When the solution became clear and transparent, the inclusion complex solution of pinocembrin in hydroxypropyl-β-cyclodextrin was obtained;

(4) Water was added to the inclusion complex solution to 200ml. The mixture was filtered through 0.22μm filter membrane. The filtrate was subpackaged into vial of 10ml (2ml/vial), and placed into freeze dryer to freeze-dry. The sterile powder for injection was obtained after the vials' stoppers were sealed.

Formula 3: Preparation of pinocembrin sodium chloride infusion

(1) To 200ml of distilled water, 20g of hydroxypropyl-β-cyclodextrin was added and dissolved with stirring. 0.5g actived carbon for infusion was added. The mixture was heated to 80℃ with stirring and kept at this temperature for 15min, then the carbon was filtered;

(2) 1g of pinocembrin was weighed and dissolved in 20ml anhydrous ethanol, then the obtained solution was poured into the hydroxypropyl-β-cyclodextrin solution mentioned above;

(3) The mixture was stirred magnetically for 20min at 40~50℃. When the solution became clear and transparent, the inclusion complex solution of pinocembrin in hydroxypropyl-β-cyclodextrin was obtained;

(4) Water was added to the inclusion complex solution to 800ml. After adding 90g sodium chloride for injection, the solution was adjusted to a pH of 8~9 and diluted to 10000ml with water. Then 10g actived carbon for injection was added, and stirred for 20min;

(5) After the carbon was removed, the solution was subpackaged in 100ml per bottle. The product was obtained after sterilizing at 121℃ for 30min.

Formula 4: Preparation of pinocembrin dextrose infusion

(1) 20g of hydroxypropyl-β-cyclodextrin was added to 200ml of distilled water and dissolved with stirring. 0.5g actived carbon for infusion was added. The mixture was heated to 80℃ by stirring and kept at this temperature for 15min, then the

carbon was filtered;

(2) 1g of pinocembrin was dissolved in 20ml anhydrous ethanol, then the obtained solution was poured into the hydroxypropyl-β-cyclodextrin solution mentioned above;

(3) The mixture was stirred magnetically for 20min at 40~50℃. When the solution became clear and transparent, the inclusion complex solution of pinocembrin in hydroxypropyl-β-cyclodextrin was obtained;

(4) Water was added to the inclusion complex solution to 800ml. After adding 500g glucose for injection, the solution was adjusted to a pH of 8~9 and diluted to 10000ml with water. Then 10g actived carbon for injection was added, and stirred for 20min;

(5) After the carbon was removed, the solution was subpackaged in 100ml per bottle. The product was obtained after sterilizing at 121℃ for 30min.

Example 24

In vivo absorption and blood concentration characteristics for pinocembrin solid active ingredient of α and β crystalline forms:

[57] 18 of SD rats, female and male each half, with body weight of 230~250g, were randomized into 3 groups, with 6 rats each group and female half. After 10 hours of fasting but free water intake, the rats were administrated with pinocembrin solid active ingredient powder of α, β or 1:1 (α+β) mixed crystalline forms, at a dose of 50mg/kg to stomach. Then the arterial blood samples at different times were taken and the contents of pinocembrin were determined. The result showed that for pinocembrin of different crystalline forms, at the same dosage by oral administration, the blood concentrations and the time to reach the peak concentration were different, wherein the blood concentration of α crystalline form was obviously lower than that of β crystalline form.

Table 11 Blood concentrations at different time for rats having been administered orally with pinocembrin samples of different crystalline forms (detected by HPLC, peak area value)

time / crystalline forms	10 min	20 min	30 min	40 min
β crystalline from	13.2	48.6	14.6	14.2
1 : 1 (α+β) crystalline forms	8.5	15.6	7.9	7.1
α crystalline form	3.8	9.7	4.4	3.5

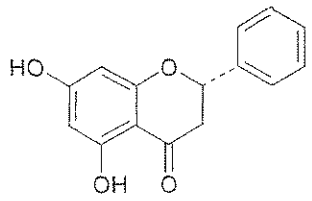
Note: the blood concentrations listed in the table were the average for the rats in each group.

References

1. Chinese patent: publication number CN1695608A
2. Cheng Yonghao, etc. synthesis of 5,7-dihydricflavanone, *chemical reagents*, 2006, 28(7): 437

What is claimed is:

1. β crystalline form of pinocembrin of formula (I):



(I)

characterized in that, when analyzed by X-ray powder (polycrystal) diffraction (CuK_α radiation), the diffraction peak locations: 2-Theta value (°) or d value (Å), and the relative strength of diffraction peak: peak height value (Height%) or peak area value (Area%), show the following characteristics:

Peak	2-Theta	d(Å)	Height%	Area%	Peak	2-Theta	d(Å)	Height%	Area%
1	7.33	12.06	100.0	66.5	**14**	29.51	3.02	1.6	0.3
2	9.41	9.40	6.2	4.9	**15**	31.03	2.88	0.7	0.4
3	11.33	7.81	6.1	4.5	**16**	34.47	2.60	1.0	1.5
4	14.07	6.29	2.9	2.2	**17**	35.45	2.53	0.4	0.2
5	14.69	6.03	27.2	17.6	**18**	37.24	2.41	1.5	0.7
6	17.49	5.07	63.9	100.0	**19**	38.15	2.36	1.2	0.9
7	19.01	4.67	2.8	1.5	**20**	40.61	2.22	3.1	2.8
8	21.49	4.13	0.1	0	**21**	42.83	2.11	1.5	1.4
9	22.11	4.02	12.9	11.2	**22**	44.89	2.02	1.6	1.3
10	23.17	3.84	19.4	9.5	**23**	46.01	1.97	2.4	1.8
11	25.91	3.44	3.3	2.5	**24**	50.36	1.81	0.7	0.8
12	27.41	3.25	31.7	27.4	**25**	56.63	1.62	1.0	0.9
13	28.31	3.15	19.0	15.1					

2. The β crystalline form of pinocembrin according to claim 1, characterized in that, the decalescence transition temperature of DSC trace is 204°C.

3. The β crystalline form of pinocembrin according to claim 1, characterized in that, the infrared absorption spectra thereof shows the following peaks: 3090.8, 2890.0, 2748.9, 2638.3, 1633.5, 1602.9, 1585.0, 1487.9, 1466.1, 1454.3, 1344.4, 1302.7, 1216.7, 1168.2, 1088.4, 1065.5, 1028.8, 1014.3, 1001.5, 975.8, 917.8, 888.2, 861.8, 826.6, 789.1, 766.6, 741.1, 715.4, 698.0, 663.7, 646.0, 620.5, 587.9, 574.8, 560.9, 527.2 and 488.4cm^{-1}, wherein the peaks 2890.0、2748.9、2638.3, 1633.5 and 1344.4 cm^{-1} are the main characteristic peaks of the β crystalline form of pinocembrin.

4. A mixed crystalline form of pinocembrin consisting of the β crystalline form of pinocembrin in any proportion according to claim 1 and α crystalline form of pinocembrin, when analyzed by X-ray single crystal diffraction, the α crystalline form shows monoclinic crystal system symmetry, the space group is $P2_1/c$, and the crystal

cell parameter values are as follows: a=5.189Å, b=24.149Å, c=10.472Å, α=90°, β=102.31° and γ=90°.

5. The crystalline form of pinocembrin according to any one of claims 1 to 4, characterized in that, said crystalline form contains no crystal water or other crystalline solvent.

6. An active pharmaceutical ingredient, comprising the crystalline form of pinocembrin according to claim 1or 4 as active ingredient, for use in the manufacture of a medicament for treating cerebral ischemia or for preventing cerebral ischemia by protecting neurovascular unit function.

7. The active pharmaceutical ingredient for use according to claim 6, daily dosage thereof ranges from 5 to 250mg, based on the crystalline solid form of pinocembrin.

8. A pharmaceutical composition, comprising therapeutically effective amount of crystalline form of pinocembrin according to any one of claims 1 and 4, in combination with one or more pharmaceutically acceptable carriers.

9. A dosage form, comprising the active pharmaceutical ingredient according to claim 6 or 7, or the composition according to claim 8, characterized in that the dosage form is tablet, capsule, pill, injection, sustained-release preparation or controlled-release preparation.

10. A method for preparing β crystalline form of pinocembrin, according to claim 1, comprising the steps of:

using α crystal form of pinocembrin as material, then

obtaining β crystalline form of pinocembrin through

(a) crystal transition by grinding, or

(b) dissolving the material completely in a solvent of pyridine or DMSO, adding water to allow precipitate, and performing filtration under reduced pressure, freeze-drying or cold spray,

wherein when analyzed by X-ray single crystal diffraction, the α crystal form shows monoclinic crystal system symmetry, the space group is $P2_1/c$, and the crystal cell parameter values are as follows: a=5.189Å, b=24.149Å, c=10.472Å, α=90°, β=102.31° and γ=90°.