DESCRIPTION

OPTICALLY ACTIVE DIHYDROPYRIDINE DERIVATIVE

Technical Field

The present invention relates to an optically active dihydropyridine derivative, a pharmacologically acceptable salt thereof having superior blood pressure lowering action, cardiac protective action, anti-arteriosclerotic action and kidney disorder ameliorative action, and a therapeutic agent or preventive agent comprising the same for hypertension, heart diseases, arteriosclerosis and kidney disorders.

Background Art

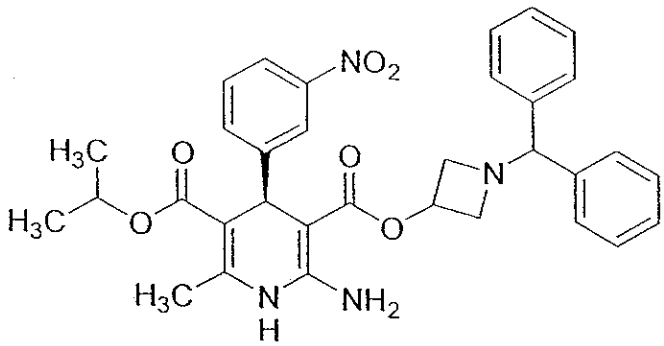
Since (±)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester (hereinafter referred to as Compound (I)), a dihydropyridine calcium antagonist, has pharmacological activities such as calcium antagonistic action, antihypertensive action, vascular dilatory action, cardiac protective action, anti-arteriosclerotic action, diuretic action, renal disorder inhibitory action and lipid peroxide formation inhibitory action and it also has a low level of toxicity, it is known to be useful as a pharmaceutical for treating diseases of the circulatory system such as hypertension, angina pectoris and arteriosclerosis (refer to, for example, Japanese Examined Patent Publication (Kokoku) No. Hei 3-31715 (specification of U.S. Patent No. 4772596)).

With the aim of the development of a superior therapeutic or preventive drug for diseases of the circulatory system, the inventors of the present invention conducted extensive research over many years on the pharmacological activity of various dihydropyridine-based calcium antagonists. As a result, it was found that (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester, which is one of the optical isomers of the racemic form, (±)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester, has particularly superior pharmacological activities such as calcium antagonistic action, antihypertensive action, vascular dilatory action, cardiac protective action, anti-

arteriosclerotic action, diuretic action, renal disorder inhibitory action and lipid peroxide formation inhibitory action, and is useful as a preventive agent or therapeutic agent (particularly therapeutic agent) for diseases of the circulatory system such as hypertension, angina pectoris and arteriosclerosis (particularly hypertension), thereby leading to completion of the present invention.

DISCLOSURE OF THE INVENTION

The (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester of the present invention is a compound having the chemical structure indicated below.



In addition, the active ingredient contained by the preventive agent or therapeutic agent for diseases of the circulatory system such as hypertension and angina pectoris of the present invention is (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester.

The (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester of the present invention may be converted to a salt in accordance with ordinary methods as desired. For example, such a salt can be obtained by treating compound (I) with the corresponding acid for 5 to 30 minutes in a solvent (such as an ether, ester or alcohol and preferably an ether) followed by filtering the precipitated crystals or distilling off the solvent under reduced pressure. Examples of such salts include salts of inorganic acids such as hydrofluorides, hydrochlorides, hydrobromides, hydroiodides, nitrates, perchlorates, sulfates or phosphates, sulfonates such as methanesulfonates, trifluoromethanesulfonates, ethanesulfonates, benzenesulfonates or p-toluenesulfonates, carboxylates such as fumarates, succinates, citrates, tartrates, oxalates or maleates, or

salts of amino acids such as glutamates or aspartates.

The (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester of the present invention or a pharmacologically acceptable salt thereof may exist in the form of their respective hydrates, and each of these along with their mixtures are included in the present invention.

MODE FOR CARRYING OUT THE INVENTION

The (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester of the present invention can be produced by optically resolving (±)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester that is produced in accordance with the method described in Japanese Examined Patent Publication (Kokoku) No. Hei 3-31715 (specification of U.S. Patent No. 4772596).

The (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester or a pharmacologically acceptable salt thereof of the present invention exhibits particularly superior pharmacological activities such as calcium antagonistic action, antihypertensive action, vascular dilatory action, cardiac protective action, anti-arteriosclerotic action, diuretic action, renal disorder inhibitory action and lipid peroxide formation inhibitory action, and is useful as a preventive agent or therapeutic agent (particularly therapeutic agent) for diseases of the circulatory system such as hypertension, angina pectoris and arteriosclerosis (particularly hypertension).

In the case where (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester or a pharmacologically acceptable salt of the present invention is used as a preventive agent or therapeutic agent for the above diseases, they can be administered per se orally in the form of a tablet, a capsule, a granule, a powder or a syrup prepared according to a known method using appropriate pharmacologically acceptable additives such as excipients, lubricants, binders, disintegrating agents, emulsifiers, stabilizers, corrigents and diluents or parenterally by an injection or a suppository.

The employable "excipient" can include an organic excipient such as sugar derivatives, e.g., lactose, sucrose, glucose, mannitol or sorbitol; starch derivatives, e.g., corn starch, potato starch, α-starch or dextrin; cellulose derivatives, e.g., crystalline cellulose; gum arabic; dextran; or pullulan; or an inorganic excipient such as silicate derivatives, e.g., light anhydrous silicic acid, synthetic aluminum silicate, calcium silicate or magnesium metasilicate aluminate; phosphates, e.g. calcium hydrogenphosphate; carbonates, e.g., calcium carbonate; or sulfates, e.g., calcium sulfate.

The employable "lubricant" can include stearic acid; metal stearates such as calcium stearate or magnesium stearate; talc; colloidal silica; waxes such as beeswax and spermaceti; boric acid; adipic acid; sulfates such as sodium sulfate; glycol; fumaric acid; sodium benzoate; DL-leucine; lauryl sulfates such as sodium lauryl sulfate and magnesium lauryl sulfate; silicic acids such as anhydrous silicic acid and silicic hydrate; or the above starch derivatives.

The employable "binder" can include hydroxypropyl cellulose, hydroxypropylmethyl cellulose, polyvinylpyrrolidone, Macrogol or a compound similar to the above excipients.

The employable "disintegrating agent" can include cellulose derivatives such as low substituted hydroxypropyl cellulose, carboxymethyl cellulose, calcium carboxymethyl cellulose or internally crosslinked sodium carboxymethyl cellulose; crosslinked polyvinylpyrrolidone; or chemically modified starch/cellulose such as carboxymethyl starch or sodium carboxymethyl starch.

The employable "emulsifier" can include colloidal clays such as bentonite or bee gum; metal hydroxides such as magnesium hydroxide or aluminum hydroxide; anionic surfactants such as sodium laurylsulfate or calcium stearate; cationic surfactants such as benzalconium chloride; or nonionic surfactants such as polyoxyethylene alkyl ether, polyoxyethylene sorbitan fatty acid ester or sucrose fatty acid ester.

The employable "stabilizer" can include parahydroxybenzoates such as methyl paraben or propyl paraben; alcohols such as chlorobutanol, benzyl alcohol or phenylethyl alcohol; benzalconium chloride; phenols such as phenol or cresol; thimerosal; dehydroacetic acid; or sorbic acid.

The employable "corrigent" can include sweeteners such as saccharin sodium

or aspartame; sour agents such as citric acid, malic acid or tartaric acid; or perfumes such as menthol, lemon extract or orange extract.

The employable "diluent" can include a compound usually used as a diluent, for example, lactose, mannitol, glucose, sucrose, calcium sulfate, calcium phosphate, hydroxypropyl cellulose, fine crystalline cellulose, water, ethanol, polyethylene glycol, propylene glycol, glycerol, starch, polyvinylpyrrolidone, magnesium metasilicate aluminate or a mixture of them.

The dose of (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester of the present invention or its pharmacologically acceptable salt can be varied depending on various conditions such as the symptoms, age and body weight of the patient. In the case of oral administration, 0.1 mg (preferably 0.5 mg) as a lower limit and 100 mg (preferably 50 mg) as an upper limit can be administered once to six times per day for adults in response to the symptoms. In the case of parenteral administration, 0.01 mg (preferably 0.05 mg) as a lower limit and 100 mg (preferably 50 mg) as an upper limit can be administered once to six times per day for adults depending on the symptoms.

In the following, the present invention is further described in detail by indicating Examples, Test Examples and Preparation Examples but the present invention is not limited to them.

[Example]

(Example 1) Preparation of (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester

(a) Preparation of (±)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester

According to Japanese Examined Patent Publication (Kokoku) No. Hei 3-31715, sodium methoxide (0.27 g) was added to a solution of 2-(3-nitrobenzylidene)acetoacetic acid isopropyl ester (1.39 g) and amidinoacetic acid (1-benzhydryl-3-azetidinyl) ester acetate (1.62 g) in isopropyl alcohol (80 ml) and the mixture was heated under reflux for 4 hours. After the reaction mixture was cooled, superfluous material was removed and the solvent was evaporated under reduced pressure. The thus obtained residue was dissolved in ethyl acetate and the mixture was

washed with water, followed by drying over anhydrous sodium sulfate. The solvent was evaporated under reduced pressure and the residue was subjected to silica gel column chromatography (toluene:ethyl acetate = 3:1) to obtain pale yellow (±)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester (2.17 g, 74%).

Melting point: 95 – 98°C;

IR spectrum (KBr, $\lambda_{max}cm^{-1}$): 3450, 3310, 1675;

Mass spectrum (CI, m/z) = 583 (M^{+}+1);

^{1}H NMR ($CDCl_3$) δ ppm: 1.08, 1.26 (6H, 2xd, J=6Hz), 2.35 (3H, s), 2.63, 3.06, 3.50, 3.62 (4H, 4xt, J=8Hz), 4.26 (1H, s), 4.9-5.0 (3H, m), 6.04 (1H, br.s), 6.11 (2H, br.s), 7.1-8.2 (14H, m).

(b) Preparation of (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester (R form)

(±)-2-Amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester (racemic form) obtained as above was subjected to high performance liquid chromatography (HPLC) under the following conditions to separate (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester (hereinafter abbreviated as R form) and (S)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester (hereinafter abbreviated as S form). Regarding the respective separated optical isomers, optical purity was measured under the following analytical conditions.

Conditions of preparative HPLC

Column: SUMICHIRAL OA-2000 (15 μm), 5.0 cm Φ X 30 cm

Mobile phase: hexane/1,2-dichloroethane/ethanol (68/29/3) (V/V/V)

Flow rate: 40 ml/min

Detector: UV (254 nm)

Column temperature: 25°C

Sample concentration: racemic form 1 g/10 ml of (chloroform: mobile phase (3:1) (V/V)) mixture

Sample pouring amount: 2 ml

Conditions of analytical HPLC

Column: SUMICHIRAL OA-2000 (5 μm), 4.6 mm Φ X 25 cm

Mobile phase: hexane/1,2-dichloroethane/ethanol (20/10/1) (V/V/V)

Flow rate: 1.0 ml/min

Detector: UV (254 nm)

Column temperature: 25°C

Retention time under the above analytical conditions: 9.1 min

Property: yellow crystalline solid

Melting point: 118.5°C

$[\alpha]^{D}_{20}$: -68.4° (c=1.00, ethanol)

Mass spectrum (CI, m/z) : 583 (M^{+}+1), 167.

NMR spectrum ($CDCl_3$, δ): 1.07 (3H, d, J=5.9Hz), 1.25 (3H, d, J=5.9Hz), 2.35 (3H, s), 2.67-2.84 (1H, br), 3.13-3.27 (1H, br), 3.57-3.68 (1H, br), 3.68-3.83 (1H, br), 4.32-4.44 (1H, br), 4.86-5.12 (3H, m), 6.08-6.36 (3H, br), 7.12-7.55 (11H, m), 7.60 (1H, d, J=8.1Hz), 8.04 (1H, d, J=8.1Hz), 8.17 (1H, s).

IR spectrum (KBr, $\lambda_{max}cm^{-1}$) : 3447, 3319, 1678.

(S)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester (S form)

Retention time under the above analytical conditions: 10.8 min

Property: yellow crystalline solid

Melting point: 118.9°C

$[\alpha]^{D}_{20}$: +68.9° (c=1.00, ethanol)

NMR spectrum ($CDCl_3$, δ ppm): 1.07 (3H, d, J=5.9Hz), 1.25 (3H, d, J=5.9Hz), 2.36 (3H, s), 2.63-2.77 (1H, br), 3.05-3.24 (1H, br), 3.52-3.64 (1H, br), 3.64-3.78 (1H, br), 4.29-4.41 (1H, br), 4.88-5.09 (3H, m), 6.04-6.29 (3H, br), 7.11-7.49 (11H, m), 7.61 (1H, d, J=7.3Hz), 8.04 (1H, d, J=8.1Hz), 8.16 (1H, s).

IR spectrum (KBr, $\lambda_{max}cm^{-1}$): 3446, 3320, 1678.

(Test Example 1)

Receptor Binding Experiment Using Porcine Myocardial Microsomes

Porcine myocardial microsomes were used for the source of the L calcium

channel, while ^{3}H-nitrendipine was used for the ligand of the L calcium channel. The microsomes (0.2 mg protein/ml), ^{3}H-nitrendipine (0.1 nM) and test drug (racemic form, R form or S form) were allowed to react at room temperature for 30 minutes in HEPES buffer (50 mM, pH 7.4) followed by measurement of the ^{3}H-nitrendipine that bound to the microsome fraction with a liquid scintillation counter. The count in the presence of 10 μM non-labeled nitrendipine (amount of non-specific binding) was then subtracted to determine the amount of specific binding. The relationship between the concentration and inhibition rate of specific binding was approximated to a logistic curve for each test drug to determine IC_{50} (50% inhibitory concentration of specific binding). The Ki value (inhibition constant) for each test drug was then determined from the following formula using the Kd (dissociation constant) of nitrendipine as separately determined from a Scatchard plot:

$$Ki = IC_{50}/(1+[L]/Kd)$$

(wherein [L] is the concentration of ^{3}H-nitrendipine). The obtained results (average of two experiments) are shown in Table 1.

(Table 1)

Compound	IC_{50} (nM)	Ki (nM)
Racemic form	3.1	2.1
R form	1.3	0.88
S form	700	460

The L calcium channel inhibitory activity of the R form was found to be roughly 500 times more potent than that of the S form, and more than twice as potent as that of the racemic form.

(Test Example 2)

Blood Pressure Lowering Action in Hypertensive Rats

Cannulas for measuring blood pressure and administering drug were inserted into the inguinal artery and inguinal vein, respectively, of male spontaneously hypertensive rats age 25 to 29 weeks followed by intravenous administration of a compound under anesthesia and measurement of blood pressure over time for the course

of 120 minutes.

The results of comparing the racemic form (20 μg/kg) and R form (10 μg/kg) are shown in Table 2, while the results of comparing the R form (3 μg/kg, 10 μg/kg) and the S form (1000 μg/kg) in a different series of experiments are shown in Table 3.

(Table 2)

Compound Dose (No. of animals)	Racemic form 20 μg/kg (4)	R form 10 μg/kg (5)
Change in blood pressure (mmHg)		
0 minutes	0±0	0±0
10 minutes	-21±2	-17±4
30 minutes	-35±4	-28±5
60 minutes	-42±6	-43±7
90 minutes	-45±6	-45±7
120 minutes	-48±7	-47±6

Mean ± standard error

(Table 3)

Compound Dose (No. of animals)	R form 3 μg/kg (3)	R form 10 μg/kg (3)	S form 1000 μg/kg (3)
Change in blood pressure (mmHg)			
0 minutes	0±0	0±0	0±0
10 minutes	-3±3	-23±5	-5±1
30 minutes	-14±3	-36±6	-18±6
60 minutes	-28±3	-49±11	-29±10
90 minutes	-34±5	-54±8	-36±7
120 minutes	-34±10	-61±6	-35±4

Mean ± standard error

According to the above results, the R form was found to demonstrate blood pressure lowering activity roughly twice as potent as that of the racemic form and roughly 300 times more potent than that of the S form.

(Preparation example 1)

Capsule

R form	50.0 mg
Lactose	128.7
Corn starch	70.0
Magnesium stearate	1.3
	250 mg

The powder of the above formulation was mixed and after the mixture passed through a screen of 60 mesh, the powder was filled in a No.3 gelatin capsule of 250 mg to make a capsule preparation.

(Preparation example 2)

Tablet

R form	50.0 mg
Lactose	124.0
Corn starch	25.0
Magnesium stearate	1.0
	200 mg

The powder of the above formulation was mixed and tablet-making was carried out using a tablet machine to make a tablet of 200 mg per one tablet. Sugar coating can be applied, if necessary, to this tablet.

[Industrial applicability]

Since (R)-2-amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester or a pharmacologically acceptable salt of the present invention shows particularly superior

pharmacological activities such as a calcium antagonistic action, an antihypertensive action, a vasodilator action, a cardiac protective action, an anti-arterosclerotic action, a diuretic action, a kidney damage inhibitory action and a lipid peroxide formation inhibitory action and it also has a low level of toxicity, it is useful as a preventive agent or therapeutic agent (particularly therapeutic agent) for circulatory system diseases such as hypertension, angina pectoris and arteriosclerosis (particularly hypertension).

Claims:

1. (R)-2-Amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester or a pharmacologically acceptable salt thereof.

2. (R)-2-Amino-1,4-dihydro-6-methyl-4-(3-nitrophenyl)-3,5-pyridinedicarboxylic acid 3-(1-diphenylmethylazetidin-3-yl) ester 5-isopropyl ester.