Description

Title of Invention: METHOD FOR PRODUCING DIAMINE DERIVATIVE

Technical Field

[0001]

The present invention relates to a method for producing a compound that exhibits an inhibitory effect on activated blood coagulation factor X (FXa), and is useful as a preventive and/or therapeutic drug for thrombotic diseases.

Background Art

[0002]

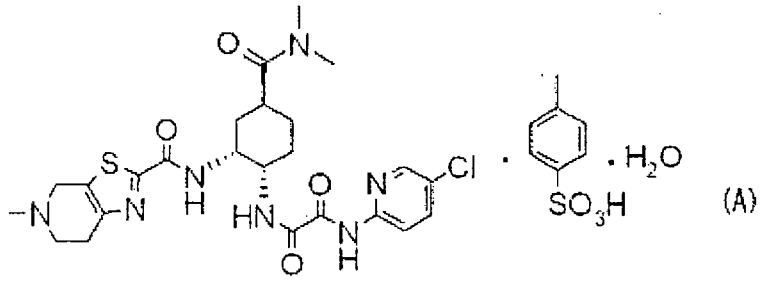
N^1-(5-chloropyridin-2-yl)-N^2-((1S,2R,4S)-4-[(dimethylamino)carbonyl]-2-{[(5-methyl-4,5,6,7-tetrahydrothiazolo[5,4-c]pyridin-2-yl)carbonyl]amino}cyclohexyl)ethanediamide p-toluenesulfonic acid monohydrate represented by the following formula (A) (hereinafter, also referred to as compound A):

[0003]

[Formula 1]

159159

G00002



(A)

[0004]

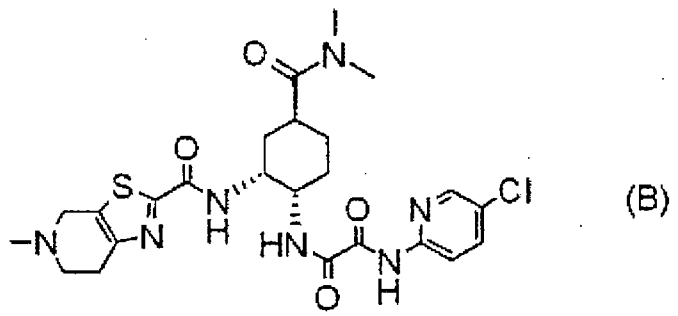
is known as a compound that exhibits an inhibitory effect on activated blood coagulation factor X (FXa), and is useful as a preventive and/or therapeutic drug for thrombotic diseases (Patent Literature 1 to 8).

[0005]

For example, a method comprising mixing thefree form of compound A represented by the following formula (B) (hereinafter, also referred to as compound B):

[0006]

[Formula 2]



(B)

[0007]

with p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate, followed by crystallization from aqueous ethanol, is known as a method for obtaining compound A (Patent Literature 1 to 8). These literature documents do not make any mention about adding p-toluenesulfonic

acid or p-toluenesulfonic acid monohydrate in a stepwise manner in the step of obtaining compound A from compound B.

Citation List

Patent Literature

[0008]

Patent Literature 1: International Publication No. WO 03/000657

Patent Literature 2: International Publication No. WO 03/000680

Patent Literature 3: International Publication No. WO 03/016302

Patent Literature 4: International Publication No. WO 04/058715

Patent Literature 5: International Publication No. WO 05/047296

Patent Literature 6: International Publication No. WO 07/032498

Patent Literature 7: International Publication No. WO 08/129846

Patent Literature 8: International Publication No. WO 08/156159

Summary of Invention

Technical Problem

[0009]

The present inventor has attempted industrial production of compound A, and consequently found that the step of obtaining compound A from compound B results in a great loss of compound A into the mother liquor during the crystallization of compound A from a solvent, and the yield differs depending on each production lot, and differences between the yields of lots are approximately 6% at the maximum. Such loss into the mother liquor or unevenness in yield is not favorable from the viewpoint of efficient production of pharmaceutical drugs. It has thus been demanded to improve these problems and produce compound A at stable high yields.

Solution to Problem

[0010]

As a result of conducting diligent studies to solve the problems, the present inventor has found that, surprisingly, compound A can be obtained at stable high yields without unevenness, with suppressed decomposition of compound B and reduced loss of compound A into the mother liquor, by an exceedingly convenient approach suitable for industrial production, in which the amount of p-toluenesulfonic acid is reduced when compound B is dissolved in a solvent, and the amount of p-toluenesulfonic acid is increased when compound A is crystallized.

Advantageous Effects of Invention

[0011]

According to the present invention, compound A can be synthesized from compound B at stable high yields without unevenness by adding p-toluenesulfonic acid or its hydrate in divided portions.

Brief Description of Drawings

[0012]

[Figure 1] Figure 1 shows the solubility of compound A obtained by varying the amount of p-toluenesulfonic acid monohydrate under conditions for crystallizing compound A (ethanol having a water content of 10%, 10°C). The ordinate depicts the solubility (mg/ml) of compound A, and the abscissa depicts the molar equivalent of p-toluenesulfonic acid monohydrate (vs. compound B).

[Figure 2] Figure 2 shows the stability of compound B obtained by varying the amount of p-toluenesulfonic acid monohydrate under conditions for dissolving compound B (ethanol having a water content of 30%, 70°C). Figure 2 depicts time-dependent (hr; abscissa) change in the amount of compound B (%; ordinate) with the initial (0 hr) amount of compound B defined as 100%.

Description of Embodiments

[0013]

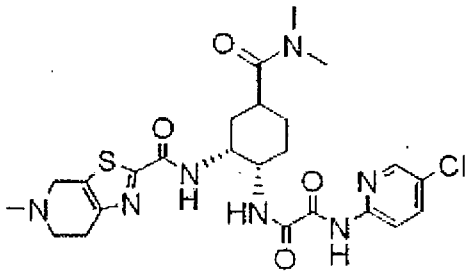
Specifically, the present invention relates to the following:

[1] a method for producing a compound represented by the following formula (A), comprising the steps of:

(a) mixing a compound represented by formula (B):

[0014]

[Formula 3]



(B)

[0015]

with p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate at less than 1 molar equivalent with respect to the compound represented by formula (B) in a solvent under heating;

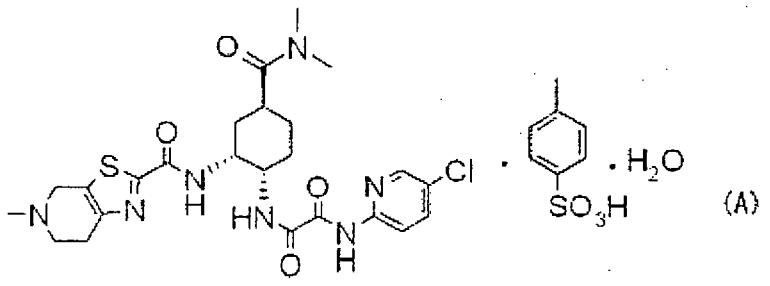
(b) adding additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate to the mixed solution under cooling, wherein

the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added in such an amount that the total molar equivalent thereof with the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is 1 molar equivalent or more with respect to the compound represented by formula (B) of step (a); and

(c) subsequently allowing the mixed solution to crystallize to obtain the compound represented by formula (A):

[0016]

[Formula 4]



(A)

;

[0017]

[2] the method according to [1], wherein the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is at 0.5 molar equivalent or more and less than 1.0 molar equivalent with respect to the compound represented by formula (B);

[3] the method according to [1] or [2], wherein the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is at 0.8 molar equivalent or more and less than 1.0 molar equivalent with respect to the compound represented by formula (B);

[4] the method according to any one of [1] to [3], wherein the total molar equivalent of the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of the step (a) and the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in step (b) is between 1.0 molar equivalent and 3.0 molar equivalents inclusive with respect to the compound represented by formula (B) of step (a);

[5] the method according to any one of [1] to [4], wherein the total molar equivalent of the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) and the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in step (b) is between 1.0 molar equivalent and 1.2 molar equivalents inclusive with respect to the compound represented by formula (B) of step (a);

[6] the method according to any one of [1] to [5], wherein the solvent is an alcohol or an aqueous alcohol;

[7] the method according to any one of [1] to [6], wherein the solvent is aqueous ethanol;

[8] the method according to any one of [1] to [7], wherein the aqueous ethanol has a water content of greater than 0% and less than or equal to 50%;

[9] the method according to any one of [1] to [8], wherein p-toluenesulfonic acid monohydrate is used;

[10] the method according to any one of [1] to [9], wherein the amount of the solvent is from 5 times to 30 times (v/w) that of compound B;

[11] the method according to any one of [1] to [10], wherein the heating temperature of step (a) is 60°C to 80°C; and

[12] the method according to any one of [1] to [11], wherein the cooling temperature of step (b) is -20°C to 40°C.

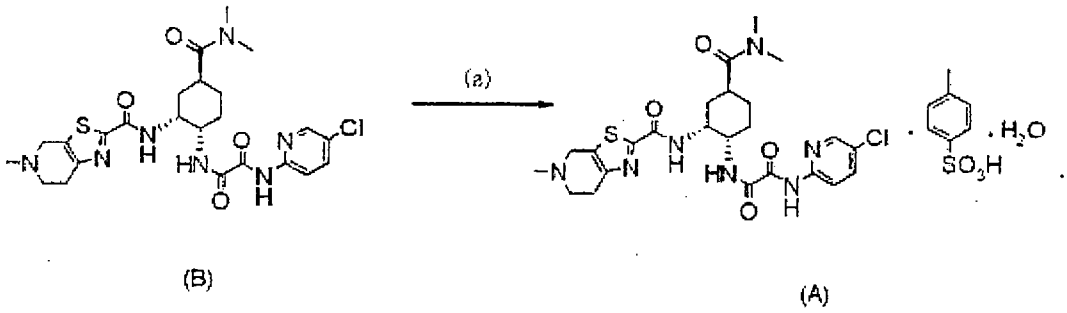
[0018]

Hereinafter, the method of the present invention will be described in detail.

[0019]

[Formula 5]

Scheme 1



[0020]

N^1-(5-chloropyridin-2-yl)-N^2-((1S,2R,4S)-4-[(dimethylamino)carbonyl]-2-{[(5-methyl-4,5,6,7-tetrahydrothiazolo[5,4-c]pyridin-2-yl)carbonyl]amino}cyclohexyl)ethanediamide represented by formula (B) is the free form of compound A and has been registered as International Nonproprietary Name (INN): edoxaban, (N-(5-chloropyridin-2-yl)-N'-[(1S,2R,4S)-4-(N,N-dimethylcarbamoyl)-2-(5-methyl-4,5,6,7-tetrahydro[1,3]thiazolo[5,4-c]pyridine-2-carboxamido)cyclohexyl]oxamide) in the World Health Organization (WHO).

[0021]

Step (a) is the step of obtaining compound A from compound B and p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate.

[0022]

According to conventional methods, although the yield in the step of obtaining compound A from compound B has been relatively favorable, there is still a great loss of compound A into the mother liquor, and yields vary depending on each production lot, and differences between the yields of lots are approximately 6% at the maximum. As a result of conducting diligent studies, the present inventor has found that, in the presence of p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate at an excess molar equivalent with respect to compound B during the mixing of the compound B and the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate in a solvent under heating, the decomposition of compound B is promoted by the excess. The present inventor has further found that the solubility of compound A is reduced when the amount of p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is an excess molar equivalent with respect to compound B during the crystallization of compound A under cooling.

[0023]

Based on these findings, the present inventor has developed a method in which the amount of p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is allowed to be a smaller molar equivalent with respect to compound B during the mixing of the compound B and the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate in a solvent under

heating, to avoid the decomposition of compound B, and the total molar equivalent of p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is allowed to be in excess with respect to compound B during the crystallization of compound A by adding additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate, to reduce the solubility of compound A and loss of compound A into the mother liquor, thereby obtaining compound A at stable high yields without unevenness between production lots.

[0024]

One of the advantages of the present invention is to obtain compound A at industrially stable high yields by an exceedingly convenient method in which p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added in divided portions.

[0025]

The present invention relates to a method for producing a compound represented by compound A, comprising mixing compound B with p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate in a solvent under heating, subsequently adding additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate under cooling, and then allowing the mixed solution to crystallize, wherein the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is at less than 1 molar equivalent with respect to compound B during the mixing under heating, and the additional p-toluenesulfonic acid or p-

toluenesulfonic acid monohydrate is added such that the total molar equivalent thereof with the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added under heating is 1 molar equivalent or more with respect to the compound B added under heating during the crystallization under cooling.

[0026]

In the present specification, the "step of mixing a compound represented by formula (B) with p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate at less than 1 molar equivalent with respect to the compound represented by formula (B) in a solvent under heating" as step (a) means mixing the compound B with the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate at less than 1 molar equivalent with respect to compound B in a solvent under heating. As shown in Figure 2, the decomposition of compound B is suppressed by allowing the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate to be at less than 1 molar equivalent with respect to compound B. The "p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate at less than 1 molar equivalent" means that the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in this step is at less than 1 molar equivalent with respect to the compound B added in this step. The "p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate at less than 1 molar equivalent" specifically means that the p-toluenesulfonic acid or p-

toluenesulfonic acid monohydrate added in this step is, for example, at 0.5 molar equivalent or more and less than 1.0 molar equivalent with respect to the compound B added in this step, and preferably means that this amount is 0.6 molar equivalent or more and less than 1.0 molar equivalent, 0.7 molar equivalent or more and less than 1.0 molar equivalent, 0.8 molar equivalent or more and less than 1.0 molar equivalent, or 0.95 molar equivalent or more and less than 1.0 molar equivalent, with respect thereto.

[0027]

The order in which the compound B and the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate are added to the solvent is not particularly limited. Preferably, compound B is added to the solvent, and then the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added. The p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate may be added in one portion or in divided portions in this step as long as it is added at less than 1 molar equivalent. Preferably, the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added in one portion.

[0028]

The timing of heating is not particularly limited and may be before, during, or in the latter half of the mixing. Preferably, the heating is performed after compound B and the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate are added to the solvent.

The heating temperature is not particularly limited and is, for example, room temperature to 80°C, preferably 60°C to 80°C. The heating time is not particularly limited, and the heating can be performed until compound B is dissolved.

[0029]

When compound B is mixed with the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate, the compound B may be in a dissolved or slurry form, and is preferably in a form dissolved by heating.

[0030]

In the present specification, the "step of adding additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate to the mixed solution under cooling" as step (b) means adding the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate to the mixed solution with or after cooling of the mixed solution.

[0031]

In the present specification, the phrase "the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added in such an amount that the total molar equivalent thereof with the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is 1 molar equivalent or more with respect to the compound represented by formula (B) of step (a)" in step (b) means that the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added in such an amount that the total molar equivalent of the p-

toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) and the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in step (b) is 1 or more with respect to the compound B added in step (a). As shown in Figure 1, the solubility of compound A can be reduced by allowing the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate to be at 1 molar equivalent or more with respect to compound B in a crystallization solvent (e.g., 10% aqueous ethanol solvent).

[0032]

The additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate "added in such an amount that the total molar equivalent thereof with the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is 1 molar equivalent or more with respect to the compound represented by formula (B) of step (a)" specifically refers to additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in such an amount that the total molar equivalent of the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in steps (a) and (b) is, for example, between 1.0 molar equivalent and 3.0 molar equivalents inclusive, preferably between 1.0 molar equivalent and 2.0 molar equivalents inclusive, more preferably between 1.0 molar equivalent and 1.5 molar equivalents inclusive, even more preferably between 1.0 molar equivalent and 1.2 molar equivalents inclusive,

further more preferably between 1.0 molar equivalent and 1.1 molar equivalents inclusive, with respect to the compound represented by formula (B) of step (a).

[0033]

For example, when p-toluenesulfonic acid monohydrate is added at 0.95 molar equivalent in step (a), p-toluenesulfonic acid monohydrate is added at 0.05 molar equivalent or more (vs. the compound B of step (a)) in step (b) in order to allow the total molar equivalent of the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in steps (a) and (b) (vs. the compound B of step (a)) to be 1 molar equivalent or more.

[0034]

The additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate may be added in one portion or in divided portions as long as the total molar equivalent with respect to the compound B of step (a) is finally 1 molar equivalent or more. Preferably, the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added in one portion.

[0035]

The timing of cooling of the crystallization solvent is not particularly limited. The additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate can be added during cooling or after cooling, preferably after cooling. The cooling temperature is not particularly limited and is, for example, -20°C to 50°C, preferably -20°C to 40°C.

[0036]

In the method of the present invention, the number of additions of the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate in divided portions is not particularly limited as long as it is 2 or more. Preferably, the number of additions is 2.

[0037]

Examples of the solvent in the method of the present invention include, but are not particularly limited to: water; alcohol solvents such as methanol, ethanol, and isopropyl alcohol; ether solvents such as diethyl ether, dipropyl ether, diisopropyl ether, and tetrahydrofuran; ester solvents such as methyl formate, ethyl formate, ethyl acetate, propyl acetate, butyl acetate, and phenyl acetate; halogenated hydrocarbon solvents such as dichloromethane, chloroform, carbon tetrachloride, dichloroethane, and tetrachloroethane; ketone solvents such as acetone, methyl ethyl ketone, and diethyl ketone; hydrocarbon solvents such as hexane, cyclohexane, benzene, and toluene; nitrogen-containing solvents such as acetonitrile, N,N-dimethylformamide, and N,N-dimethylacetamide; and mixed solvents thereof. The solvent used in the present steps is preferably an alcohol or a mixed solvent of water and an alcohol (also referred to as an aqueous alcohol), more preferably ethanol or a mixed solvent of water and ethanol (also referred to as aqueous ethanol).

[0038]

When an aqueous alcohol (preferably, aqueous ethanol) is used as the solvent in the method of the present invention, its water content is not particularly limited and is, for example, a content of from higher than 0% to 50%, preferably between 5% and 35% inclusive. When an aqueous alcohol (preferably, aqeuous ethanol) is used as the solvent in the method of the present invention, it is preferred to change the water content between the heating and cooling procedures. For example, it is preferred to use an aqueous alcohol of between 25% and 35% inclusive (e.g., aqueous ethanol of between 25% and 35% inclusive) in the heating procedure and use an aqueous alcohol of between 5% and 25% inclusive (e.g., aqueous ethanol of between 5% and 25% inclusive) in the cooling procedure.

[0039]

The amount of the solvent in the method of the present invention is not particularly limited and is, for example, 5 times to 50 times (v/w (volume/weight)), preferably 5 times to 30 times (v/w), that of compound B.

[0040]

The compound A thus obtained exhibits a high inhibitory effect on activated blood coagulation factor X (FXa) and as such, is useful as an anticoagulant agent or a preventive and/or therapeutic agent for thrombus or embolism. Compound A is useful as a pharmaceutical drug for mammals including humans, an activated blood coagulation factor Xa inhibitor, an anticoagulant agent,

a preventive and/or therapeutic agent for thrombus or embolism, a preventive and/or therapeutic agent for thrombotic disease, for example, a preventive and/or therapeutic agent for cerebral infarction, cerebral embolism, myocardial infarction, angina pectoris, unstable angina, acute coronary syndrome (ACS), pulmonary infarction, pulmonary embolism, thromboembolism or seizure accompanying nonvalvular atrial fibrillation (NVAF), deep vein thrombosis, disseminated intravascular coagulation syndrome, thrombosis after prosthetic valve/joint replacement, thromboembolism after total hip replacement (THR), thrombosis and reocclusion after revascularization, thrombosis at the time of extracorporeal circulation, blood coagulation at the time of blood collection, Buerger's disease, thromboembolism accompanying systemic inflammatory response syndrome (SIRS), or thromboembolism accompanying multiple organ dysfunction syndrome (MODS), or a bulk pharmaceutical for these preventive and/or therapeutic agents.

[0041]

A pharmaceutical drug containing compound A as an active ingredient is preferably provided in the form of a pharmaceutical composition containing compound A and one or two or more pharmaceutical additives. The dosage form of the pharmaceutical drug of the present invention is not particularly limited. It can be administered orally or parenterally and is preferably administered orally.

[0042]

Examples of pharmacologically or pharmaceutically acceptable additives used in the production of the pharmaceutical composition can include, but are not limited to, excipients, disintegrants or disintegration aids, binders, lubricants, coating agents, pigments, diluents, bases, solubilizers or solubilization aids, tonicity agents, pH adjusters, stabilizers, propellants, and adhesives.

[0043]

Examples of preparations suitable for oral administration can include tablets, powders, granules, capsules, solutions, syrups, elixirs, and oily or aqueous suspensions. Moreover, examples of preparations suitable for parenteral administration can include injections, drops, suppositories, inhalants, and patches.

[0044]

The dose of the pharmaceutical drug of the present invention is not particularly limited, and can be selected appropriately according to various conditions such as the age, body weight, and conditions of a patient. It is preferred to administer the pharmaceutical drug of the present invention at a dose of 1 mg to 1000 mg, preferably 5 mg to 500 mg, more preferably 5 mg to 300 mg, even more preferably 5 mg to 100 mg of the active ingredient per day in an adult, which is administered in one portion or in several portions, preferably in one portion or in two portions, per day, according to the conditions.

[0045]

Hereinafter, Examples will be described. However, the present invention is not intended to be limited to them.

Examples

[0046]

In the Examples below, p-toluenesulfonic acid monohydrate is also referred to as $TsOH \cdot H_2O$.

[0047]

(Example 1) Synthesis of N^1-(5-chloropyridin-2-yl)-N^2-((1S,2R,4S)-4-[(dimethylamino)carbonyl]-2-{[(5-methyl-4,5,6,7-tetrahydrothiazolo[5,4-c]pyridin-2-yl)carbonyl]amino}cyclohexyl)ethanediamide (compound B)

Compound B was synthesized according to a method described in Patent Literature 1 to 8.

[0048]

(Example 2) Synthesis of N^1-(5-chloropyridin-2-yl)-N^2-((1S,2R,4S)-4-[(dimethylamino)carbonyl]-2-{[(5-methyl-4,5,6,7-tetrahydrothiazolo[5,4-c]pyridin-2-yl)carbonyl]amino}cyclohexyl)ethanediamide p-toluenesulfonic acid monohydrate (compound A)

$TsOH \cdot H_2O$ (49.5 g) was added to a mixed solution of N^1-(5-chloropyridin-2-yl)-N^2-((1S,2R,4S)-4-[(dimethylamino)carbonyl]-2-{[(5-methyl-4,5,6,7-tetrahydrothiazolo[5,4-c]pyridin-2-yl)carbonyl]amino}cyclohexyl)ethanediamide (150 g), ethanol (735 ml), and water (315 ml), and the mixture was

heated to 70°C. The dissolved solution was filtered through a filter, and the filter was washed with 15% aqueous ethanol (300 ml) and ethanol (150 ml). Subsequently, a mixed solution of the filtered mother liquor and the washes was slowly cooled, and $TsOH \cdot H_2O$ (7.8 g) and ethanol (2100 ml) were added thereto. After stirring at 10°C for 1 hour, crystals were collected by filtration, to obtain 188.9 g of the title compound.

[0049]

(Test Example 1)

The solubility of compound A was determined using varying amounts of $TsOH \cdot H_2O$ under conditions for crystallizing compound A (ethanol having a water content of 10%, 10°C). Specifically, compound A, compound B, and $TsOH \cdot H_2O$ were added in the combinations shown below to 10 ml of ethanol having a water content of 10%. The resulting slurry was stirred at 10°C, and crystals were collected by filtration. Then, the content of the compound A contained in the filtered mother liquor was measured by HPLC (column: Shiseido CAPCELL PAK CN UG120 (4.6 × 250 mm), column temperature: 40°C, flow rate: 1.0 ml/min., mobile phase: acetonitrile:0.02 M phosphate buffer (pH 7.0) = 30:70).

[0050]

[Table 1]

Molar equivalent of $TsOH \cdot H_2O$ with respect to compound B[*1]	Compound A (mg)	Compound B (mg)	$TsOH \cdot H_2O$ (mg)
1.2	561	0	29
1.1	561	0	14
1.05	561	0	7
1.02	561	0	3
1.0	561	0	0
0.98	550	8	0
0.95	533	21	0
0.90	505	42	0

[0051]

[*1] "Molar equivalent of $TsOH \cdot H_2O$ with respect to compound B" described here refers to the ratio of the sum of the molar number of $TsOH \cdot H_2O$ and the molar number of $TsOH \cdot H_2O$ present as a part of the compound A to the sum of the molar number of the compound B and the molar number of the compound B present as a part of the compound A.

[0052]

The results are shown in Figure 1.

[0053]

It was found that the solubility of compound A is reduced when the amount of $TsOH \cdot H_2O$ is larger than 1.00 molar equivalent of $TsOH \cdot H_2O$ with respect to compound B, and the solubility thereof is increased when the amount of $TsOH \cdot H_2O$ is smaller than this molar equivalent.

[0054]

(Test Example 2)

The stability of compound B was determined using varying amounts of $TsOH \cdot H_2O$ under conditions for dissolving compound B in a solvent (ethanol having a water content of 30%, 70°C). Specifically, 7 ml of ethanol having a water content of 30% and $TsOH \cdot H_2O$ were added in combinations shown below to 1.0 g of compound B, followed by dissolution at 70°C. The content of the compound B was measured at constant time intervals by HPLC (column: Shiseido CAPCELL PAK CN UG120 (4.6 × 250 mm), column temperature: 40°C, flow rate: 1.0 ml/min., mobile phase: acetonitrile:0.02 M phosphate buffer (pH 7.0) = 30:70).

[0055]

[Table 2]

Molar equivalent of $TsOH \cdot H_2O$ with respect to compound B	$TsOH \cdot H_2O$ (mg)
1.2	416
1.1	382
1.05	364
1.02	354
1.0	347
0.9	312
0.8	278

[0056]

The results are shown in Figure 2.

[0057]

It was demonstrated that in the presence of $TsOH \cdot H_2O$ at more than 1.0 molar equivalent (vs. compound B) under conditions for dissolving compound B, the decomposition of compound B (decrease in compound B content) is

promoted with the excess, whereas the decomposition is suppressed in the presence thereof at less than 1.0 molar equivalent.

[0058]

(Test Example 3)

Based on the results of Test Examples 1 and 2, the present inventor had an idea that the excess of p-toluenesulfonic acid that promotes the decomposition of compound B be avoided for dissolving compound B under high temperatures, and the excess of p-toluenesulfonic acid under low temperatures be created for crystallization to reduce the solubility of compound A, resulting in improvement in the yield of step (a). An attempt was made to perform a p-toluenesulfonic acid division method reflecting this idea.

[0059]

Specifically, 21 ml of water, 49 ml of ethanol, and 3.30 g of $TsOH \cdot H_2O$ (0.95 molar equivalent with respect to compound B) were added to 10.0 g of compound B, followed by dissolution at 70°C. The dissolved solution was filtered through a filter, and the filter was washed with a mixed solution of 3 ml of water and 17 ml of ethanol. Subsequently, a mixed solution of the filtered mother liquor and the washes was slowly cooled, and 521 mg of $TsOH \cdot H_2O$ (0.15 molar equivalent with respect to compound B) and 150 ml of ethanol were added thereto. After stirring at 10°C, crystals of compound A were collected by filtration, and its yield was determined. Moreover,

two lots of compound B were used to evaluate reproducibility. To prepare a control, 21 ml of water, 49 ml of ethanol, and 3.47 g of $TsOH \cdot H_2O$ (1.0 molar equivalent with respect to compound B) were added to 10.0 g of compound B, followed by dissolution at 70°C. The dissolved solution was filtered through a filter, and the filter was washed with a mixed solution of 3 ml of water and 17 ml of ethanol. Subsequently, a mixed solution of the filtered mother liquor and the washes was slowly cooled, and 150 ml of ethanol was added thereto. After stirring at 10°C, crystals of compound A were collected by filtration, and its yield was determined.

[0060]

A loss into the mother liquor means the compound A remaining in the mother liquor without being deposited as crystals. Loss into mother liquor (%) described in Table 1 was calculated by converting the weight of the compound A remaining in the mother liquor into the weight of the compound B and indicating this weight as a ratio (%) to the weight of the compound B before the start of the reaction.

[0061]

The results are shown in Table 3.

[0062]

[Table 3]

	Molar equivalent of $TsOH \cdot H_2O$*1			Yield of compound A (%)*2	Loss into mother liquor (%)*2
	Molar equivalent of $TsOH \cdot H_2O$ added in dissolution step (70°C)	Molar equivalent of $TsOH \cdot H_2O$ added after slow cooling (10°C)	Total molar equivalent of $TsOH \cdot H_2O$		
1	0.95	0.15	1.1	93.8	4.2
2	0.95	0.15	1.1	94.2	3.1
3	1.0	0	1.0	90.5	6.7

[0063]

*1: vs. compound B

*2: vs. compound B

It was demonstrated that compound A can be obtained at high yields with favorable reproducibility by adding $TsOH \cdot H_2O$ in divided portions even if different lots of compound B are used.

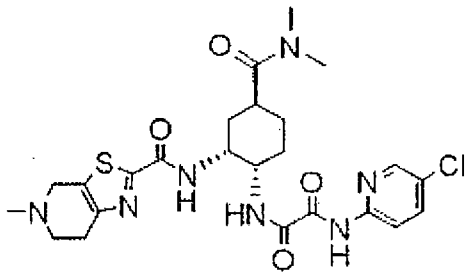
Claims

[Claim 1]

A method for producing a compound represented by the following formula (A), comprising the steps of:

(a) mixing a compound represented by formula (B):

[Formula 1]



(B)

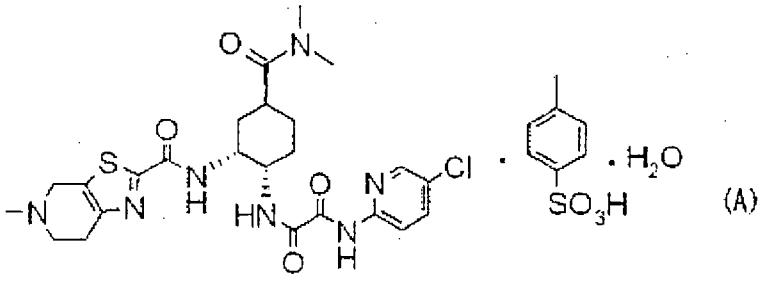
with p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate at less than 1 molar equivalent with respect to the compound represented by formula (B) in a solvent under heating;

(b) adding additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate to the mixed solution under cooling, wherein

the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate is added in such an amount that the total molar equivalent thereof with the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is 1 molar equivalent or more with respect to the compound represented by formula (B) of step (a); and

(c) subsequently allowing the mixed solution to crystallize to obtain the compound represented by formula (A):

[Formula 2]



(A)

[Claim 2]

The method according to claim 1, wherein the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is at 0.5 molar equivalent or more and less than 1.0 molar equivalent with respect to the compound represented by formula (B).

[Claim 3]

The method according to claim 1 or 2, wherein the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) is at 0.8 molar equivalent or more and less than 1.0 molar equivalent with respect to the compound represented by formula (B).

[Claim 4]

The method according to any one of claims 1 to 3, wherein the total molar equivalent of the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) and the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in step (b) is between 1.0 molar equivalent and 3.0 molar equivalents inclusive with respect to the compound represented by formula (B) of step (a).

[Claim 5]

The method according to any one of claims 1 to 3, wherein the total molar equivalent of the p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate of step (a) and the additional p-toluenesulfonic acid or p-toluenesulfonic acid monohydrate added in step (b) is between 1.0 molar equivalent and 1.2 molar equivalents inclusive with respect to the compound represented by formula (B) of step (a).

[Claim 6]

The method according to any one of claims 1 to 5, wherein the solvent is an alcohol or an aqueous alcohol.

[Claim 7]

The method according to any one of claims 1 to 6, wherein the solvent is aqueous ethanol.

[Claim 8]

The method according to any one of claims 1 to 7, wherein the aqueous ethanol has a water content of greater than 0% and less than or equal to 50%.

[Claim 9]

The method according to any one of claims 1 to 8, wherein p-toluenesulfonic acid monohydrate is used.

[Claim 10]

The method according to any one of claims 1 to 9, wherein the amount of the solvent is from 5 times to 30 times (v/w) that of compound B.

[Claim 11]

The method according to any one of claims 1 to 10, wherein the heating temperature of step (a) is 60°C to 80°C.

[Claim 12]

The method according to any one of claims 1 to 11, wherein the cooling temperature of step (b) is -20°C to 40°C.