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METHOD FOR PRODUCING HETEROCYCLIDENE ACETAMIDE DERIVATIVE

Abstract

The present invention provides, a novel method for producing a compound represented by formula (I) and a novel method for producing a compound represented by formula (B) or a salt thereof, which are intermediates in the production of formula (I).

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This application is a Continuation of copending application Ser. No. 17/486,265, filed on Sep. 27, 2021, which is a Continuation of PCT International Application No. PCT/JP2020/022827, filed on Jun. 10, 2020, which claims priority under 35 U.S.C. 119(a) to Patent Application Nos. 201910783254.8, filed in China on Aug. 23, 2019; PCT/JP2019/036451, filed in Japan on Sep. 18, 2019; and 202010355546.4, filed in China on Apr. 29, 2020, all of which are hereby expressly incorporated by reference into the present application.

TECHNICAL FIELD
[0002] The present invention relates to a new method for producing (E)-2-(7-trifluoromethylchroman-4-ylidene)-N-((7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide represented by Formula (I) which is a heterocyclidene acetamide derivative. Furthermore, the present invention relates to a new method for producing (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol represented by Formula (B) or a salt thereof, which is an intermediate useful for producing the compound represented by Formula (I).
BACKGROUND ART
[0003] [0002](E)-2-(7-trifluoromethylchroman-4-ylidene)-N-((7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide represented by Formula (I) is a transient receptor potential vanilloid 1 (TRPV1) antagonist, and is anticipated as a preventive and/or therapeutic agent for diseases involving the TRPV1 receptor (for example, pain (for example, neuropathic pain, diabetic neuralgia, postoperative pain, osteoarthrosis, rheumatoid arthritis pain, inflammatory pain, cancer pain, migraine and the like), nervous disorders, nerve damage, neurodegeneration, chronic obstructive pulmonary disease, asthma, rhinitis, inflammation of mucous membranes such as in the eyes, nervous skin disease, inflammatory skin disease, allergic disease, urinary incontinence, urge incontinence, overactive bladder, cystitis, pruritus, and the like) (Patent Literature 1).
##STR00001##
[0004] WO 2007/010383 (Patent Literature 1) discloses a method for producing the compound represented by Formula (I). In the document, the compound represented by Formula (I) is produced in steps of <Step 1> to <Step 3> shown in the following (scheme A). [0005] <Step 1> A compound represented by Formula (IM-k) is obtained by performing a condensation reaction using 8-amino-3,4-dihydronaphthalen-2(1H)-one (Formula (IM-3)) produced according to a method known from a document (for example, WO 2005/040100 (Patent Literature 2) and the like) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (Formula (CA-1) in CAS No. 920334-15-2, Non Patent Literature 1) and a condensing agent (1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (EDCI-HCl)). [0006] <Step 2> The compound represented by Formula (IM-k) is reduced with sodium borohydride to obtain a compound represented by Formula (I-Rac). [0007] <Step 3> The compound represented by Formula (I-Rac) is optically resolved on an optically active

column to obtain a compound represented by Formula (I), and a compound represented by Formula (I-S) which is an isomer thereof.
[0008] However, in this production method, the compound represented by Formula (I) is obtained by performing the column resolution in the final step, and it is difficult to reuse the compound represented by Formula (I-S) obtained after the column resolution.
##STR00002##
[0009] Meanwhile, WO 2005/040100 (Patent Literature 2), WO 2003/095420 (Patent Literature 3), WO 2005/040119 (Patent Literature 4), and WO 2010/127855 (Patent Literature 5) disclose methods for producing the compound represented by Formula (B), which corresponds to a partial structural formula of Formula (I).
##STR00003##
[0010] In these literatures, 8-amino-3,4-dihydronaphthalen-2(1H)-one (Formula (IM-3)) is obtained through reactions of alkylation of a phenol group, Birch reduction, and deprotection of an alkyl group using 8-aminonaphthalen-2-ol (Formula (SM-1)) as a starting material, and thereby the compound represented by Formula (B) is produced by asymmetrically reduction of it in the presence of a Ru catalyst (scheme 1).
[0011] However, in these production methods, the Birch reduction is used in one step, and the metal (Ru) catalyst is used in the asymmetric reduction in the final step, therefore a step of reducing a residual rate of the metal (Ru) in the obtained compound is required.
##STR00004##
[0012] Furthermore, WO 2009/050289 (Patent Literature 6), WO 2010/045401 (Patent Literature 7), and WO 2010/045402 (Patent Literature 8) also disclose methods for producing the compound represented by Formula (B). In these literatures, the compound represented by Formula (B) is produced by a resolution using an optically active column after induced into racemic 8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (Formula A) by selectively reducing a naphthalene ring using 8-aminonaphthalen-2-ol (Formula (SM-1)) as a starting material (scheme 2).
[0013] However, in this production method, it is difficult to reuse other isomers (S-forms) obtained after the column resolution.
##STR00005##
[0014] Furthermore, WO 2009/055749 (Patent Literature 9) also discloses a method for producing the compound represented by Formula (B). In this literature, the compound represented by Formula (B) is produced by column resolution of the diastereomer obtained after diastereomeric resolution of a chiral auxiliary introduced racemate represented by Formula (A) (scheme 3).
[0015] However, also in this production method, it is difficult to reuse other isomers (S-forms) obtained after the column resolution.
##STR00006##
[0016] The methods for producing the compound represented by Formula (B) disclosed in the respective literatures have issues such as types of reactions in the production process, reagents to be used, and difficulty in reuse of other isomers obtained after resolving a racemate or diastereoisomer on a column. Therefore, an improved production method is required for large-scale synthesis or industrial production of the compound represented by Formula (B). That is, when considering large-scale synthesis or industrial production of the compound represented by Formula (B), it is required to find a new production method different from the production methods described in the respective literatures. Since a production method for large-scale synthesis of the compound represented by Formula (B) in a high yield and high optical purity has not yet been found, it is thought that the above-mentioned issues in the production of the compound represented by Formula (B) can be solved if a method for a large scale synthesis of the compound represented by Formula (B) in fewer steps, high chemical yield, and high optical purity is found.
[0017] U.S. Patent Application No. 5136103 (Patent Literature 10) and the like disclose a method for oxidizing a secondary alcohol to a ketone using 2,2,6,6-tetramethylpiperidine-1-oxyl radical

(TEMPO) as an oxidant. However, a TEMPO oxidation reaction in which 1,2,3,4-tetrahydronaphthalene (for example, tert-butyl-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate and the like) which has a substituted amino group and a hydroxyl group in a molecule is used as a raw material is not known. Furthermore, a TEMPO oxidation reaction by flow chemistry (flow reaction) in which the compound is used as a raw material is also not known.
[0018] U.S. Patent Application No. 5225339 (Patent Literature 11) and U.S. Patent Application No. 5342767 (Patent Literature 12) disclose reduction of ketones by a reductase derived from *Lactobacillus* kefir, but an enzymatic reduction adapted to keto compounds such as protecting group-substituted amino-3,4-dihydronaphthalen-2(1H)-one or 0-tetralone is not disclosed.
[0019] Advanced Synthesis & Catalysis, 350 (14+15), p2322-2328, 2008 (Non Patent Literature 2) discloses enzymatic reduction of ketones of α- or β-tetralone (reductase: derived from *Lactobacillus* kefir). However, it is clearly stated that a reductive reaction of ketones of 0-tetralone does not proceed when a reductase derived from *Lactobacillus* kefir is used.
[0020] WO 2018/205948 (Patent Literature 13) discloses 8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol (CAS No. 444619-84-5, Non Patent Literature 3) and its production method, but (R)-8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol, which is a chiral form thereof, and its prodcution method are not known.
[0021] CAS Registry discloses 8-fluoro-1,2,3,4-tetrahydronaphthalen-2-ol (CAS No. 1823867-35-1, Non Patent Literature 4), but (R)-8-fluoro-1,2,3,4-tetrahydronaphthalen-2-ol, which is a chiral form thereof, and its production method are not known. Furthermore, CAS Registry discloses 8-chloro-1,2,3,4-tetrahydronaphthalen-2-ol (CAS No. 1823929-47-0, Non Patent Literature 5), but (R)-8-chloro-1,2,3,4-tetrahydronaphthalen-2-ol, which is a chiral form thereof, and its production method are not known.
[0022] Bioorganic & Medicinal Chemistry Letters, 18 (6), pl830-1834, 2008 (Non Patent Literature 6) discloses a method for producing 8-amino-6-fluoro-1,2,3,4-tetrahydronaphthalen-2-ol (yield 18%) by an amination reaction of 8-bromo-6-fluoro-1,2,3,4-tetrahydronaphthalen-2-ol with a Pd catalyst (Pd.sub.2(dba).sub.3) and tert-butyl carbamate, and subsequently deprotection of a Boc group.

CITATION LIST

Patent Literature

[0023] [Patent Literature 1] WO 2007/010383 [0024] [Patent Literature 2] WO 2005/040100
[0025] [Patent Literature 3] WO 2003/095420 [0026] [Patent Literature 4] WO 2005/040119
[0027] [Patent Literature 5] WO 2010/127855 [0028] [Patent Literature 6] WO 2009/050289
[0029] [Patent Literature 7] WO 2010/045401 [0030] [Patent Literature 8] WO 2010/045402
[0031] [Patent Literature 9] WO 2009/055749 [0032] [Patent Literature 10]U.S. Patent Application No. 5136103 [0033] [Patent Literature 11]U.S. Patent Application No. 5225339 [0034] [Patent Literature 12]U.S. Patent Application No. 5342767 [0035] [Patent Literature 13] WO 2018/205948

Non Patent Literature

[0036] [Non Patent Literature 1] CAS No. 920334-15-2 [0037] [Non Patent Literature 2] Advanced Synthesis & Catalysis, 350 (14+15), p2322-2328, 2008 [0038] [Non Patent Literature 3] CAS No. 444619-84-5 [0039] [Non Patent Literature 4] CAS No. 1823867-35-1 [0040] [Non Patent Literature 5] CAS No. 1823929-47-0 [0041] [Non Patent Literature 6] Bioorganic & Medicinal Chemistry Letters, 18(6), p1830-1834, 2008

SUMMARY OF INVENTION

Technical Problem

[0042] Under such circumstances, a new method for producing the above-mentioned compound represented by Formula (I) has been required.

Solution to Problem

[0043] The inventors of the present invention have repeatedly conducted extensive research in order to solve the above-described problems. As a result, the inventors have found a new method

for easily producing the compound represented by Formula (I) in a high yield, and completed the present invention based on this finding. That is, the inventors have found a new method for producing the compound represented by Formula (I) by a condensation reaction of a carboxylic acid represented by Formula (CA-1) and an amino alcohol represented by Formula (B) or a salt thereof using DMT-MM (4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride) (CAS No: 3945-69-5) as a condensation agent (Scheme B).
##STR00007##
[0044] The inventors have further found a new method for producing the compound represented by Formula (B) or a salt thereof, which is an intermediate useful for producing the compound represented by Formula (I), and completed the present invention based on this finding (Scheme C-1).
##STR00008##
[0045] The inventors have still further found a new method for producing the compound represented by Formula (B) or a salt thereof, which is an intermediate useful for producing the compound represented by Formula (I), and completed the present invention based on this finding (Scheme C-2).
##STR00009##
Effect of the Invention
[0046] The present invention provides a new method for producing the compound represented by Formula (I), or the compound represented by Formula (B) or a salt thereof. The present invention preferably provides an efficient production method suitable for large-scale synthesis or industrial production of the compound represented by Formula (I), or the compound represented by Formula (B) or a salt thereof. Production methods according to some aspects of the present invention are methods that enable production of the compound represented by Formula (I), or the compound represented by Formula (B) or a salt thereof in a high yield and industrially advantageously, and therefore these methods are highly useful industrially. Furthermore, some other aspects provide new compounds represented by Formulas (A-7) and (A8) which are raw materials for obtaining the compound represented by Formula (B) and a salt thereof.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0047] FIG. **1** is an example of a reaction device used in flow chemistry;
[0048] FIG. **2** is a figure showing a crystal structure of an HBr salt of a compound represented by Formula (B); and
[0049] FIG. **3** is a figure showing a crystal structure of a compound represented by Formula (I).
DESCRIPTION OF EMBODIMENTS
[Aspects of the Present Invention]
[0050] A method for producing a compound represented by Formula (I) is provided. Some aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (A) as a starting material. Some other aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (A-5) as a starting material. Still other aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (A-6) as a starting material. Still other aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (A-7) as a starting material.
[0051] Still other aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (SM8) as a starting material. Still other aspects are a method for producing the compound represented by Formula (I) by using a compound represented

by Formula (SM8-BR) as a starting material. Still other aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (A8) as a starting material. Still other aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (A8-BR) as a starting material. Still other aspects are a method for producing the compound represented by Formula (I) by using a compound represented by Formula (B) as a starting material.

[0052] Furthermore, a method for producing the compound represented by Formula (B) or a salt thereof is also provided. Some aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (A) as a starting material. Some other aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (A-5) as a starting material. Still other aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (A-6) as a starting material. Still other aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (A-7) as a starting material.

[0053] Still other aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (SM8) as a starting material. Still other aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (SM8-BR) as a starting material. Still other aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (A8) as a starting material. Still other aspects are a method for producing the compound represented by Formula (B) or a salt thereof by using the compound represented by Formula (A8-BR) as a starting material.

[0054] Further still other aspects are a method for producing the compound represented by Formula (A-6) by using the compound represented by Formula (A-5) or Formula (A-7) as a starting material. Further still other aspects are a method for producing the compound represented by Formula (A-7) by using the compound represented by Formula (A-6) as a starting material. Further still other aspects are the compound represented by Formula (A-7).

[0055] Still other aspects are a method for producing the compound represented by Formula (A8) by using the compound represented by Formula (SM8) as a starting material. Still other aspects are a method for producing the compound represented by Formula (A8-BR) by using the compound represented by Formula (SM8-BR) as a starting material. Still other aspects are the compound represented by Formula (A8) and the compound represented by Formula (A8-BR).

[0056] Hereinafter, each of the aspects will be specifically described. [0057] [1]A first aspect is a method for producing a compound represented by Formula (B) or a salt thereof, the method comprising: tert-butoxycarbonylating an amino group of a compound represented by Formula (A) to obtain a compound represented by Formula (A-5); causing an oxidation reaction of the compound represented by Formula (A-5) to obtain a compound represented by Formula (A-6); asymmetrically reducing the compound represented by Formula (A-6) to obtain a compound represented by Formula (A-7); and deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7) to obtain the compound represented by Formula (B) or a salt thereof.

##STR00010## [0058] [2]A second aspect is a method for producing a compound represented by Formula (B) or a salt thereof, the method comprising: causing an oxidation reaction of a compound represented by Formula (A-5) to obtain a compound represented by Formula (A-6); asymmetrically reducing the compound represented by Formula (A-6) to obtain a compound represented by Formula (A-7); and deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7) to obtain the compound represented by Formula (B) or a salt thereof.

##STR00011## [0059] [3]A third aspect is a method for producing a compound represented by Formula (B) or a salt thereof, the method comprising: asymmetrically reducing a compound represented by Formula (A-6) to obtain a compound represented by Formula (A-7); and

deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7) to obtain the compound represented by Formula (B) or a salt thereof.
##STR00012## [0060] [4]A fourth aspect is a method for producing a compound represented by Formula (B) or a salt thereof, the method comprising: deprotecting a tert-butoxycarbonyl group of a compound represented by Formula (A-7) to obtain the compound represented by Formula (B) or a salt thereof.
##STR00013## [0061] [4B]A 4B-th aspect is a method for producing a salt of a compound represented by Formula (B), the method comprising: adding an acid to the compound represented by Formula (B) to obtain the salt of the compound represented by Formula (B).
##STR00014## [0062] [4B-1] In the above aspect [4B], the acid used in obtaining a salt of the compound represented by Formula (B) is preferably an inorganic acid or an organic acid, is more preferably an inorganic acid, and is even more preferably hydrobromic acid. [0063] [5]A fifth aspect is a method for producing a compound represented by Formula (A-6), the method comprising: causing an oxidation reaction of a compound represented by Formula (A-5) to obtain a compound represented by Formula (A-6).
##STR00015## [0064] [6]A sixth aspect is a method for producing a compound represented by Formula (A-7), the method comprising: asymmetrically reducing a compound represented by Formula (A-6) to obtain the compound represented by Formula (A-7).
##STR00016## [0065] [7]A seventh aspect is a method for producing a compound represented by Formula (I), the method comprising: causing a condensation reaction of a compound represented by Formula (B) or a salt thereof and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00017## [0066] [8] An eighth aspect is a method for producing a compound represented by Formula (I), the method comprising: tert-butoxycarbonylating an amino group of a compound represented by Formula (A) to obtain a compound represented by Formula (A-5); causing an oxidation reaction of the compound represented by Formula (A-5) to obtain a compound represented by Formula (A-6); asymmetrically reducing the compound represented by Formula (A-6) to obtain a compound represented by Formula (A-7); deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7) to obtain a compound represented by Formula (B) or a salt thereof; and causing a condensation reaction of the compound represented by Formula (B) or a salt thereof and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00018## ##STR00019## [0067] [9]A ninth aspect is a method for producing a compound represented by Formula (I), the method comprising: causing an oxidation reaction of a compound represented by Formula (A-5) to obtain a compound represented by Formula (A-6); asymmetrically reducing the compound represented by Formula (A-6) to obtain a compound represented by Formula (A-7); deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7) to obtain a compound represented by Formula (B) or a salt thereof; and causing a condensation reaction of the compound represented by Formula (B) or a salt thereof and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00020## [0068] [10]A tenth aspect is a method for producing a compound represented by Formula (I), the method comprising: asymmetrically reducing a compound represented by Formula (A-6) to obtain a compound represented by Formula (A-7); deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7) to obtain a compound represented by Formula (B) or a salt thereof; and causing a condensation reaction of the compound represented by Formula (B) or a salt thereof and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00021## [0069] [11] An eleventh aspect is a method for producing a compound represented by Formula (I), the method comprising: deprotecting a tert-butoxycarbonyl group of a compound

represented by Formula (A-7) to obtain a compound represented by Formula (B) or a salt thereof; and causing a condensation reaction of the compound represented by Formula (B) or a salt thereof and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00022## [0070] [12]A twelfth aspect is a compound represented by Formula (A-7).
##STR00023##
[0071] In each of the above aspects, “deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7) to obtain the compound represented by Formula (B) or a salt thereof” may further comprise: [0072] desalting the salt of the compound represented by Formula (B), which is obtained by deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7), to obtain the compound represented by Formula (B); or [0073] converting the compound represented by Formula (B), which is obtained by deprotecting a tert-butoxycarbonyl group of the compound represented by Formula (A-7), to a salt thereof to obtain the salt of the compound represented by Formula (B). [0074] [13]A thirteenth aspect is a method for producing a compound represented by Formula (B), the method comprising: asymmetrically reducing a keto group of a compound represented by Formula (SM8) to obtain a compound represented by Formula (A8); and reacting the compound represented by Formula (A8) with ammonia water in the presence of a catalyst to obtain the compound represented by Formula (B).
##STR00024##
[in Formula (SM8), X is a halogen atom.]
##STR00025##
[in Formula (A8), X is a halogen atom.] [0075] [13-1] In the above aspect [13], each X in the compound represented by Formula (SM8) and the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0076] [13-2] In the above aspect [13], the catalyst is preferably a Pd catalyst or a Cu catalyst, is more preferably a Cu catalyst, and is even more preferably Cu.sub.2O. [0077] [13-3]A 13-3-th aspect is a method for producing a salt of the compound represented by Formula (B) in the above aspect [13], the method comprising: adding an inorganic acid or an organic acid to the compound represented by Formula (B) to obtain the salt of the compound represented by Formula (B). The inorganic acid or organic acid used for obtaining the salt of the compound represented by Formula (B) is preferably an inorganic acid, is more preferably hydrochloric acid or hydrobromic acid, and is even more preferably hydrobromic acid.
[0078] In the present specification, unless otherwise specified, “halogen atom” refers to, for example, a fluorine atom, a chlorine atom, a bromine atom, an iodine atom, and the like. [0079] [14]A fourteenth aspect is a method for producing a compound represented by Formula (B), the method comprising: reacting a compound represented by Formula (A8) with ammonia water in the presence of a catalyst to obtain the compound represented by Formula (B).
##STR00026##
[in Formula (A8), X is a halogen atom.] [0080] [14-1] In the above aspect [14], X in the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0081] [14-2] In the above aspect [14], the catalyst is preferably a Pd catalyst or a Cu catalyst, is more preferably a Cu catalyst, and is even more preferably Cu.sub.2O. [0082] [14-3]A 14-3-th aspect is a method for producing a salt of the compound represented by Formula (B) in the above aspect [14], the method comprising: adding an inorganic acid or an organic acid to the compound represented by Formula (B) to obtain the salt of the compound represented by Formula (B). The inorganic acid or organic acid used for obtaining the salt of the compound represented by Formula (B) is preferably an inorganic acid, is more preferably hydrochloric acid or hydrobromic acid, and is even more preferably hydrobromic acid.
[0083] [15]A fifteenth aspect is a method for producing a compound represented by Formula (A8), the method comprising: asymmetrically reducing a keto group of a compound represented by

Formula (SM8) to obtain the compound represented by Formula (A8).
##STR00027##
[in Formula (A8), X is a halogen atom.]
##STR00028##
[in Formula (SM8), X is a halogen atom.] [0084] [15-1] In the above aspect [15], each X in the compound represented by Formula (SM8) and the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0085] [16]A sixteenth aspect is a compound represented by Formula (A8).
##STR00029##
[in Formula (A8), X is a halogen atom.] [0086] [16-1] In the above aspect [16], X in the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0087] [17]A seventeenth aspect is a method for producing a compound represented by Formula (I), the method comprising: asymmetrically reducing a keto group of a compound represented by Formula (SM8) to obtain a compound represented by Formula (A8); reacting the compound represented by Formula (A8) with ammonia water in the presence of a catalyst to obtain a compound represented by Formula (B); and causing a condensation reaction of the compound represented by Formula (B) and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00030##
[in Formula (SM8), X is a halogen atom.]
##STR00031##
[in Formula (A8), X is a halogen atom.]
##STR00032## [0088] [17-1] In the above aspect [17], each X in the compound represented by Formula (SM8) and the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0089] [17-2] In the above aspect [17], the catalyst is preferably a Pd catalyst or a Cu catalyst, is more preferably a Cu catalyst, and is even more preferably Cu.sub.2O. [0090] [18] An eighteenth aspect is a method for producing a compound represented by Formula (I), the method comprising: asymmetrically reducing a keto group of a compound represented by Formula (SM8) to obtain a compound represented by Formula (A8); reacting the compound represented by Formula (A8) with ammonia water in the presence of a catalyst to obtain a compound represented by Formula (B); adding an acid to the compound represented by Formula (B) to obtain a salt of the compound represented by Formula (B); and causing a condensation reaction of the salt of the compound represented by Formula (B) and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00033##
[in Formula (SM8), X is a halogen atom.]
##STR00034##
[in Formula (A8), X is a halogen atom.]
##STR00035## [0091] [18-1] In the above aspect [18], each X in the compound represented by Formula (SM8) and the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0092] [18-2] In the above aspect [18], the catalyst is preferably a Pd catalyst or a Cu catalyst, is more preferably a Cu catalyst, and is even more preferably Cu.sub.2O. [0093] [18-3] In the above aspect [18], the acid used in obtaining a salt of the compound represented by Formula (B) is preferably an inorganic acid or an organic acid, is more preferably an inorganic acid, is even more preferably hydrochloric acid or hydrobromic acid, and is particularly preferably hydrobromic acid. [0094] [19]A nineteenth aspect is a method for producing a compound represented by Formula (I), the method comprising: reacting a compound represented by Formula (A8) with ammonia water in the presence of a catalyst to obtain a compound represented by Formula (B); and causing a condensation reaction of

the compound represented by Formula (B) and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00036##
[in Formula (A8), X is a halogen atom.]
##STR00037## [0095] [19-1] In the above aspect [19], each X in the compound represented by Formula (SM8) and the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0096] [19-2] In the above aspect [19], the catalyst is preferably a Pd catalyst or a Cu catalyst, is more preferably a Cu catalyst, and is even more preferably Cu.sub.2O. [0097] [20]A twentieth aspect is a method for producing a compound represented by Formula (I), the method comprising: reacting a compound represented by Formula (A8) with ammonia water in the presence of a catalyst to obtain a compound represented by Formula (B); adding an acid to the compound represented by Formula (B) to obtain a salt of the compound represented by Formula (B); and causing a condensation reaction of the salt of the compound represented by Formula (B) and a compound represented by Formula (CA-1) using DMT-MM as a condensation agent to obtain the compound represented by Formula (I).
##STR00038##
[in Formula (A8), X is a halogen atom.]
##STR00039## [0098] [20-1] In the above aspect [20], each X in the compound represented by Formula (SM8) and the compound represented by Formula (A8) is preferably a fluorine atom, a chlorine atom, or a bromine atom, and is more preferably a bromine atom. [0099] [20-2] In the above aspect [20], the catalyst is preferably a Pd catalyst or a Cu catalyst, is more preferably a Cu catalyst, and is even more preferably Cu.sub.2O. [0100] [20-3] In the above aspect [20], the acid used in obtaining a salt of the compound represented by Formula (B) is preferably an inorganic acid or an organic acid, is more preferably an inorganic acid, is even more preferably hydrochloric acid or hydrobromic acid, and is particularly preferably hydrobromic acid.
[0101] Hereinafter, each of the reactions in the above-described aspects will be described in detail.
<Step of Producing Compound Represented by Formula (A-5)>
[0102] The compound represented by Formula (A-5) is obtained by tert-butoxycarbonylating an amino group of the compound represented by Formula (A).
[0103] Examples of tert-butoxycarbonylating agents include di-tert-butyl dicarbonate (Boc.sub.2O), 2-(tert-butoxycarbonyloxyimino)-2-phenylacetonitrile (Boc-ON), N-tert-butoxycarbonylimidazole, 2-(tert-butoxycarbonylthio)-4,6-dimethylpyrimidine, 1-tert-butoxycarbonyl-1,2,4-triazole, tert-butyl phenyl carbonate, tert-butyl carbazate, N-(tert-butoxycarbonyloxy)phthalimide, and the like. Di-tert-butyl dicarbonate (Boc.sub.2O) and 2-(tert-butoxycarbonyloxyimino)-2-phenylacetonitrile (Boc-ON) are preferable, and di-tert-butyl dicarbonate (Boc.sub.2O) is more preferable. A usage amount of a tert-butoxycarbonylating agent is generally 1.0 to 2.0 molar equivalents, is preferably 1.1 to 1.8 molar equivalents, and is more preferably 1.3 to 1.65 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A).
[0104] The reaction may be performed in the presence of a solvent. As the solvent, it is possible to use for example, a solvent not involved in the reaction such as dichloromethane, acetonitrile, diethyl ether, tetrahydrofuran, 1,2-dimethoxyethane, 1,4-dioxane, tert-butyl ether, toluene, water and the like, or a mixed solvent thereof. The solvent can be appropriately selected depending on the type of tert-butoxycarbonylating agent to be used. Tetrahydrofuran, 1,4-dioxane, a mixed solvent of tetrahydrofuran-water, and a mixed solvent of 1,4-dioxane-water are preferable, and tetrahydrofuran, a mixed solvent of tetrahydrofuran-water, and a mixed solvent of 1,4-dioxane-water are more preferable.
[0105] The reaction may be performed in the presence of a base. As the base, it is possible to use bases such as sodium hydrogen carbonate, potassium carbonate, sodium carbonate, triethylamine,

N,N-diisopropylethylamine, pyridine and the like. The base can be appropriately selected depending on the type of tert-butoxycarbonylating agent to be used. Sodium hydrogen carbonate, triethylamine, and pyridine are preferable, and sodium hydrogen carbonate is more preferable.
[0106] A usage amount of the base is, for example, 1.0 to 4.0 molar equivalents, is preferably 1.0 to 3.5 molar equivalents, and is more preferably 1.0 to 3.2 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A).
[0107] Regarding a reaction temperature, the reaction can be performed within, for example, a range of −78° C. to a temperature at which the solvent is refluxed, a range of −78° C. to room temperature, a range of 0° C. to a temperature at which the solvent is refluxed, or a range of 0° C. to room temperature. The reaction temperature can be appropriately selected depending on the type of tert-butoxycarbonylating agent to be used. A reaction temperature is preferably within a range of 20° C. to 55° C.
<Step of Producing Compound Represented by Formula (A-6)>
[0108] The compound represented by Formula (A-6) is obtained by causing an oxidation reaction of the compound represented by Formula (A-5) or the compound represented by Formula (A-7).
[0109] Examples of oxidation reactions include Swern oxidation, PCC oxidation (chromate oxidation), Dess-Martin oxidation, TPAP oxidation, TEMPO oxidation, and the like. TEMPO oxidation is preferable.
[0110] The TEMPO oxidation is generally a reaction in which TEMPO and a reoxidant are combined as an oxidizing agent to oxidize a substrate such as alcohol. In addition, the TEMPO oxidation can also be performed in the presence of a base.
[0111] In the oxidation reaction, for example, a batch method, and flow chemistry (a reaction in flow mode using a continuous stirred tank reactor (CSTR)) are used.
[0112] A usage amount of the oxidant in the oxidation reaction is generally 1.0 to 2.2 molar equivalents, is preferably 1.2 to 2.1 molar equivalents, and is more preferably 1.4 to 2.0 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A-5) or the compound represented by Formula (A-7).
[0113] A usage amount of TEMPO in the TEMPO oxidation is generally 0.01 to 1.0 molar equivalents, is preferably 0.05 to 0.7 molar equivalents, and is more preferably 0.5 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A-5) or the compound represented by Formula (A-7).
[0114] Examples of reoxidants in the TEMPO oxidation include sodium hypochlorite (NaClO), iodobenzene diacetate, and the like. A usage amount of sodium hypochlorite in the TEMPO oxidation is generally 1.0 to 2.5 molar equivalents, is preferably 1.1 to 2.2 molar equivalents, and is more preferably 1.2 to 2.0 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A-5) or the compound represented by Formula (A-7).
[0115] The TEMPO oxidation can be performed in the presence of a base, and for example, a usage amount of NaHCO.sub.3 as a base is generally 1.0 to 5.0 molar equivalents, is preferably 2.0 to 4.5 molar equivalents, and is more preferably 4.0 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A-5) or the compound represented by Formula (A-7).
[0116] A usage amount of KBr in the TEMPO oxidation is generally 0.01 to 0.30 molar equivalents, is preferably 0.02 to 0.25 molar equivalents, and is more preferably 0.05 to 0.2 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A-5) or the compound represented by Formula (A-7).
[0117] The oxidation reaction (for example, the TEMPO oxidation) may be performed in the presence of a solvent. As the solvent, it is possible to use, for example, a solvent not involved in the reaction such as dichloromethane, 1,2-dichloroethane, chloroform, acetonitrile, acetone, water and the like, or a mixed solvent thereof. The solvent can be appropriately selected depending on the type of oxidation reaction to be used. In the TEMPO oxidation, dichloromethane, acetonitrile, acetone, water, or a mixed solvent thereof is preferable; dichloromethane, acetonitrile, acetone,

water, dichloromethane-water, acetonitrile-water, or acetone-water is more preferable; and dichloromethane, water, or dichloromethane-water is even more preferable.
[0118] Regarding an oxidation reaction (for example, a reaction temperature in the TEMPO oxidation), the reaction can be performed within, for example, a range of −78° C. to a temperature at which the solvent is refluxed, a range of −78° C. to room temperature, a range of 0° C. to a temperature at which the solvent is refluxed, or a range of 0° C. to room temperature. The reaction temperature can be appropriately selected depending on the type of oxidation reaction to be used. In the TEMPO oxidation, a reaction temperature is preferably within a range of −2° C. to 5° C.
[0119] It is also possible to use a reducing agent such as Na.sub.2S.sub.2O.sub.4 (aqueous solution) to remove TEMPO after the TEMPO oxidation reaction.
<Step of Producing Compound Represented by Formula (A-7)>
[0120] The compound represented by Formula (A-7) is obtained by asymmetrically reducing the ketone compound represented by Formula (A-6).
[0121] Examples of asymmetric reductions include asymmetric reduction using a chemical catalyst or the like, asymmetric reduction using a biocatalyst (yeast, fungus, mold, enzyme, and the like), and the like. Asymmetric reduction using an enzyme is preferable, asymmetric reduction using a ketone reductase (ketoreductase: KRED) as an enzyme is more preferable, and asymmetric reduction using a ketone reductase derived from *Lactobacillus* sp. as an enzyme is particularly preferable. The asymmetric reduction using a ketone reductase is performed using a ketone reductase, a coenzyme, and a coenzyme regeneration system. Typical examples of coenzymes for ketone reductases include NADP. Furthermore, as a typical example of a coenzyme regeneration system that regenerates NADP, which is a coenzyme, oxidation of glucose by glucose dehydrogenase (GDH) is known. Furthermore, the asymmetric reduction using a ketone reductase is preferably performed in a solvent in the presence of a buffer solution.
[0122] A usage amount of the reducing agent in the asymmetric reduction, for example, in the asymmetric reduction using a chemical catalyst or the like, is generally 1.0 to 2.2 molar equivalents, and is preferably 1.2 to 2.0 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A-6).
[0123] In the asymmetric reduction using an enzyme, a usage amount of the enzyme is generally 1.0 to 25 times, is preferably 5 to 20 times, and is more preferably 10 times an amount of 1 g of the compound represented by Formula (A-6).
[0124] In the asymmetric reduction using a ketone reductase derived from *Lactobacillus* sp., a usage amount of the enzyme is generally 1.0 to 25 times, is preferably 5 to 20 times, and is more preferably 10 times an amount of 1 g of the compound represented by Formula (A-6).
[0125] D-glucose may be used in the asymmetric reduction using an enzyme. When D-glucose is used, a usage amount of D-glucose is generally 1.0 to 5.0 times, is preferably 1.5 to 3.5 times, and is more preferably 2.0 times an amount of 1 g of the compound represented by Formula (A-6).
[0126] In the asymmetric reduction using an enzyme, glucose dehydrogenase (GDH) may be used. When glucose dehydrogenase (GDH) is used, a usage amount of glucose dehydrogenase (GDH) is generally 0.01 to 0.5 times, is preferably 0.05 to 0.2 times, and is more preferably 0.05 times or 0.2 times an amount of 1 g of the compound represented by Formula (A-6).
[0127] In the asymmetric reduction using an enzyme, a coenzyme may be used, and for example, nicotinamide adenine dinucleotide phosphate (NADP) may be used. When nicotinamide adenine dinucleotide phosphate (NADP) is used, a usage amount nicotinamide adenine dinucleotide phosphate (NADP) is generally 0.01 to 0.5 times, is preferably 0.025 to 0.1 times, and is more preferably 0.025 times or 0.1 times an amount of 1 g of the compound represented by Formula (A-6).
[0128] The asymmetric reduction may be performed in the presence of a solvent. As the solvent, it is possible to use, for example, a solvent not involved in the reaction such as alcohol-based solvents such as methanol, ethanol, propanol, butanol and the like; hydrocarbon-based solvents

such as heptane, hexane, octane, toluene and the like; ether-based solvents such as tetrahydrofuran, 1,4-dioxane, butyl ether and the like; polar solvents such as acetonitrile, dimethyl sulfoxide, dimethylformamide and the like; and water, or a mixed solvent thereof. The solvent can be appropriately selected depending on the type of enzyme to be used. In the asymmetric reduction using an enzyme, as the buffer solution, it is possible to use, for example, buffer solutions such as a phosphate buffer solution, a potassium phosphate buffer solution (which can be prepared from, for example, reagents such as K.sub.2HPO.sub.4-3H.sub.20, KH.sub.2PO.sub.4 and the like), a Tris/HCl buffer solution, a sodium tetraborate-hydrochloric acid buffer solution, a triethanolamine buffer solution and the like. The buffer solution can be appropriately selected depending on the type of enzyme to be used.

[0129] In the asymmetric reduction using a ketone reductase derived from *Lactobacillus* sp., the solvent is preferably dimethyl sulfoxide, toluene, water, or a mixed solvent thereof, and is more preferably toluene, water, or a mixed solvent of toluene-water.

[0130] In the asymmetric reduction using an enzyme, a usage amount of the organic solvent is generally 1.0 to 15 times, is preferably 2 to 13 times, and is more preferably 5.0 times an amount of 1 g of the compound represented by Formula (A-6).

[0131] In the asymmetric reduction using an enzyme, a usage amount of the buffer solution is generally 10 to 40 times, is preferably 15 to 30 times, and is more preferably 30 times an amount of 1 g of the compound represented by Formula (A-6).

[0132] In the asymmetric reduction using an enzyme, a pH of a reaction solution is generally 6.0 to 7.5, is preferably 6.0 to 6.5, 6.5 to 7.0, or 6.0 to 7.0, and is more preferably 6.0 to 7.0.

[0133] A reaction temperature when performing the asymmetric reduction can be appropriately selected from a reaction temperature within, for example, a range of −78° C. to a temperature at which the solvent is refluxed, a range of −78° C. to room temperature, a range of 0° C. to a temperature at which the solvent is refluxed, a range of 0° C. to room temperature, and the like. A reaction temperature is preferably within a range of 0° C. to room temperature.

[0134] A reaction temperature when performing the asymmetric reduction using an enzyme is generally within a range of temperatures at which the enzyme is not deactivated, and it is preferably within a range of 20° C. to 60° C., is more preferably within a range of 20° C. to 25° C. or a range of 50° C. to 60° C., and is even more preferably within a range of 20° C. to 25° C.

<Step of Producing Compound Represented by Formula (B) or Salt Thereof from Formula (A-7)>

[0135] The compound represented by Formula (B) or a salt thereof is obtained by deprotecting a tert-butoxycarbonyl group of the chiral alcohol compound represented by Formula (A-7), by desalting the salt of the compound represented by Formula (B) obtained by deprotecting the tert-butoxycarbonyl group, or by converting the compound represented by Formula (B) obtained by deprotecting the tert-butoxycarbonyl group to its salt.

[0136] Examples of reagents used for deprotecting the tert-butoxycarbonyl group generally include acidic reagents, and the reagent is preferably hydrogen chloride (which is hydrochloric acid, or which is generated in a solvent system using acetyl chloride and an alcohol solvent such as methanol, ethanol, propanol, and the like), hydrogen bromide, and trifluoroacetic acid; is more preferably hydrogen chloride (which is hydrochloric acid, or which is generated in a solvent system using acetyl chloride and an alcohol solvent such as methanol, ethanol, propanol, and the like) and trifluoroacetic acid; and is particularly preferably hydrogen chloride (which is hydrochloric acid, or which is generated in a solvent system using acetyl chloride and an alcohol solvent such as methanol, ethanol, propanol, and the like).

[0137] Deprotection of the tert-butoxycarbonyl group may be performed in the presence of a solvent. Examples of solvents for deprotecting the tert-butoxycarbonyl group include solvents not involved in the reaction such as halogen-based solvents such as dichloromethane, chloroform, 1,2-dichloroethane and the like; alcohol-based solvents such as methanol, ethanol, propanol, butanol and the like; hydrocarbon-based solvents such as heptane, hexane, octane, toluene and the like;

ether-based solvents such as tetrahydrofuran, 1,4-dioxane, butyl ether and the like; polar solvents such as acetone, acetonitrile, dimethyl sulfoxide, dimethylformamide and the like; and water, or a mixed solvent thereof, and halogen-based solvents such as dichloromethane, chloroform, 1,2-dichloroethane and the like, and alcohol-based solvents such as methanol, ethanol, propanol, butanol and the like are preferable, and propanol (n-propanol) is more preferable.

[0138] A reaction temperature when deprotecting the tert-butoxycarbonyl group can be appropriately selected from a reaction temperature within, for example, a range of −78° C. to a temperature at which the solvent is refluxed, a range of −78° C. to room temperature, a range of 0° C. to a temperature at which the solvent is refluxed, a range of 0° C. to room temperature, and the like. A reaction temperature is preferably within a range of 0° C. to 55° C.

[0139] It is possible to desalt the salt of the compound represented by Formula (B) by using a base. As the base for desalting the salt of the compound represented by Formula (B), it is possible to use bases such as sodium hydrogen carbonate, potassium carbonate, sodium carbonate, triethylamine, N,N-diisopropylethylamine, pyridine and the like, and sodium hydrogen carbonate, potassium carbonate, and sodium carbonate are preferable, and sodium hydrogen carbonate is more preferable.

[0140] Desalting of the salt of the compound represented by Formula (B) can be performed in the presence of a solvent. Examples of solvents for desalting the salt of the compound represented by Formula (B) include solvents not involved in the reaction such as halogen-based solvents such as dichloromethane, chloroform, 1,2-dichloroethane and the like; ether-based solvents such as tetrahydrofuran, 1,4-dioxane, butyl ether and the like; polar solvents such as ethyl acetate, isopropyl acetate, acetonitrile, dimethyl sulfoxide, dimethylformamide and the like; and water, or a mixed solvent thereof, and ethyl acetate, isopropyl acetate, water, and a mixed solvent of ethyl acetate-water or isopropyl acetate-water are preferable, and a mixed solvent of ethyl acetate-water is more preferable.

<Step of Producing the Salt from Compound Represented by Formula (B)>

[0141] The compound represented by Formula (B) can be converted to a salt using an organic acid or an inorganic acid. As an acid for converting the compound represented by Formula (B) to a salt thereof, it is possible to use, for example, acids such as hydrochloric acid, hydrobromic acid, hydriodic acid, nitric acid, sulfuric acid, phosphoric acid, formic acid, acetic acid, trifluoroacetic acid, propionic acid, butyric acid, valeric acid, enanthic acid, capric acid, myristic acid, palmitic acid, stearic acid, lactic acid, sorbic acid, mandelic acid, oxalic acid, malonic acid, succinic acid, fumaric acid, maleic acid, malic acid, tartaric acid, citric acid, benzoic acid, salicylic acid, phthalic acid, cinnamic acid, glycolic acid, pyruvic acid, oxylic acid, salicylic acid, N-acetylcysteine, methanesulfonic acid, benzenesulfonic acid, p-toluenesulfonic acid, aspartic acid, glutamic acid and the like, and hydrochloric acid, hydrobromic acid, nitric acid, sulfuric acid, phosphoric acid, acetic acid, phthalic acid, fumaric acid, oxalic acid, tartaric acid, maleic acid, citric acid, succinic acid, methanesulfonic acid, and p-toluenesulfonic acid are preferable, hydrochloric acid and hydrobromic acid are more preferable, and hydrobromic acid is even more preferable.

[0142] The conversion of the compound represented by Formula (B) into a salt thereof can be performed in the presence of a solvent. Examples of solvent for converting the compound represented by Formula (B) to a salt thereof include solvents not involved in the reaction such as halogen-based solvents such as dichloromethane, chloroform, 1,2-dichloroethane and the like; ether-based solvents such as tetrahydrofuran, 1,4-dioxane, butyl ether and the like; alcohol-based solvents such as methanol, ethanol and the like; polar solvents such as ethyl acetate, isopropyl acetate, acetonitrile, dimethyl sulfoxide, dimethylformamide and the like; and water, or a mixed solvent thereof, and a solvent not involved in the reaction such as dichloromethane, chloroform, 1,2-dichloroethane, tetrahydrofuran, 1,4-dioxane, methanol, ethanol, ethyl acetate, and water, or a mixed solvent thereof is preferable, and ethyl acetate, water, or ethyl acetate-water is more preferable.

<Step of Producing Compound Represented by Formula (A8)>
[0143] The compound represented by Formula (A8) is obtained by asymmetrically reducing the ketone compound represented by Formula (SM8).
[0144] Examples of asymmetric reductions include asymmetric reduction using a chemical catalyst or the like, asymmetric reduction using a biocatalyst (yeast, fungus, mold, enzyme, and the like), and the like. Asymmetric reduction using an enzyme is preferable, asymmetric reduction using a ketone reductase (KRED: ketoreductase) as an enzyme is more preferable, and asymmetric reduction using a ketone reductase derived from *Escherichia coli* sp. as an enzyme is particularly preferable. The asymmetric reduction using a ketone reductase is performed using a ketone reductase, a coenzyme, and a coenzyme regeneration system. Typical examples of coenzymes for ketone reductases include NADP. Furthermore, as a typical example of a coenzyme regeneration system that regenerates NADP, which is a coenzyme, oxidation of glucose by glucose dehydrogenase (GDH) is known. Furthermore, the asymmetric reduction using a ketone reductase is preferably performed in a solvent in the presence of a buffer solution.
[0145] A usage amount of the reducing agent in the asymmetric reduction, for example, in the asymmetric reduction using a chemical catalyst or the like, is generally 1.0 to 2.2 molar equivalents, and is preferably 1.2 to 2.0 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (SM8).
[0146] In the asymmetric reduction using an enzyme, a usage amount of the enzyme is generally 0.01 to 0.1 times, is preferably 0.02 to 0.07 times, and is more preferably 0.047 to 0.05 times an amount of 1 g of the compound represented by Formula (SM8).
[0147] In the asymmetric reduction using a ketone reductase (KRED) derived from *Escherichia coli* sp., a usage amount of the enzyme is 0.01 to 0.1 times, is preferably 0.02 to 0.07 times, and is more preferably 0.047 to 0.05 times an amount of 1 g of the compound represented by Formula (SM8).
[0148] D-glucose may be used in the asymmetric reduction using an enzyme. When D-glucose is used, a usage amount of D-glucose is generally 1.0 to 5.0 times, is preferably 1.5 to 3.5 times, and is more preferably 1.9 to 2.0 times an amount of 1 g of the compound represented by Formula (SM8).
[0149] In the asymmetric reduction using an enzyme, glucose dehydrogenase (GDH) may be used. When glucose dehydrogenase (GDH) is used, a usage amount of glucose dehydrogenase (GDH) is generally 0.01 to 0.1 times, is preferably 0.01 to 0.05 times, and is more preferably 0.019 to 0.02 times an amount of 1 g of the compound represented by Formula (SM8).
[0150] In the asymmetric reduction using an enzyme, nicotinamide adenine dinucleotide phosphate (NADP) may be used. When nicotinamide adenine dinucleotide phosphate (NADP) is used, a usage amount nicotinamide adenine dinucleotide phosphate (NADP) is generally 0.001 to 0.1 times, is preferably 0.005 to 0.05 times, and is more preferably 0.009 to 0.01 times an amount of 1 g of the compound represented by Formula (SM8).
[0151] The asymmetric reduction may be performed in the presence of a solvent. As the solvent, it is possible to use, for example, a solvent not involved in the reaction such as alcohol-based solvents such as methanol, ethanol, propanol, butanol and the like; hydrocarbon-based solvents such as heptane, hexane, octane, toluene and the like; ether-based solvents such as tetrahydrofuran, 1,4-dioxane, butyl ether and the like; polar solvents such as acetone, acetonitrile, dimethyl sulfoxide, dimethylformamide and the like; and water, or a mixed solvent thereof, and the solvent can be appropriately selected depending on the type of enzyme to be used. In the asymmetric reduction using an enzyme, as the buffer solution, it is possible to use, for example, buffer solutions such as a phosphate buffer solution, a potassium phosphate buffer solution (which can be prepared from, for example, reagents such as K.sub.2HPO.sub.4-3H.sub.2O and KH.sub.2PO.sub.4), a Tris/HCl buffer solution, a sodium tetraborate-hydrochloric acid buffer solution, a triethanolamine buffer solution and the like, and the buffer solution can be appropriately selected depending on the

type of enzyme to be used.
[0152] In the asymmetric reduction using a ketone reductase (KRED) derived from *Escherichia coli* sp., the solvent is preferably dimethyl sulfoxide, water, or a mixed solvent of dimethyl sulfoxide-water.
[0153] In the asymmetric reduction using a ketone reductase (KRED) derived from *Escherichia coli* sp., a usage amount of the organic solvent is generally 1.0 to 10 times, is preferably 2 to 5 times, and is more preferably 2.5 to 3.0 times an amount of 1 g of the compound represented by Formula (SM8).
[0154] In the asymmetric reduction using a ketone reductase (KRED) derived from *Escherichia coli* sp., a usage amount of the buffer solution is generally 10 to 40 times, is preferably 15 to 30 times, and is more preferably 28 to 30 times an amount of 1 g of the compound represented by Formula (SM8).
[0155] In the asymmetric reduction using an enzyme, a pH of a reaction solution is generally 6.0 to 7.5, and is preferably 6.5 to 7.0.
[0156] A reaction temperature when performing the asymmetric reduction can be appropriately selected from a reaction temperature within, for example, a range of −78° C. to a temperature at which the solvent is refluxed, a range of −78° C. to room temperature, a range of 0° C. to a temperature at which the solvent is refluxed, a range of 0° C. to room temperature, and the like. A reaction temperature is preferably within a range of 0° C. to room temperature.
[0157] A reaction temperature when performing the asymmetric reduction using an enzyme is generally within a range of temperatures at which the enzyme is not deactivated, and it is preferably within a range of 20° C. to 60° C., is more preferably within a range of 20° C. to 35° C., and is even more preferably within a range of 20° C. to 30° C.
[0158] Unless otherwise specified in the present specification, when Formula (SM8) is referred to, it includes low-order formulas thereof (for example, Formula (SM8-FL), Formula (SM8-CL), Formula (SM8-BR), Formula (SM8-ID), and the like). Similarly, unless otherwise specified in the present specification, when Formula (A8) is referred to, it includes low-order formulas thereof (for example, Formula (A8-FL), Formula (A8-CL), Formula (A8-BR), Formula (A8-ID), and the like).
[0159] Furthermore, Formula (SM8-FL) is a compound in which X=fluorine atom in the compound represented by Formula (SM8). Formula (SM8-CL) is a compound in which X=chlorine atom in the compound represented by Formula (SM8). Formula (SM8-BR) is a compound in which X=bromine atom in the compound represented by Formula (SM8). Formula (SM8-ID) is a compound in which X=iodine atom in the compound represented by Formula (SM8).
[0160] Furthermore, Formula (A8-FL) is a compound in which X=fluorine atom in the compound represented by Formula (A8). Formula (A8-CL) is a compound in which X=chlorine atom in the compound represented by Formula (A8). Formula (A8-BR) is a compound in which X=bromine atom in the compound represented by Formula (A8). Formula (A8-ID) is a compound in which X=iodine atom in the compound represented by Formula (A8).
<Step of Producing Compound Represented by Formula (B) from Formula (A8)>
[0161] The compound represented by Formula (B) is obtained by causing an amination reaction of the compound represented by Formula (A8) in the presence of a metal catalyst using ammonia (ammonia water (for example, 25%, 28%, 30%, and the like)). A concentration (%) of ammonia water is w/w % or w/v %.
[0162] Examples of catalysts for the amination reaction of the compound represented by Formula (A8) using ammonia for a nitrogen source include a Pd catalyst, a Cu catalyst, and the like. Examples of Pd catalysts include a Pd.sub.2(dba).sub.3 PdCl.sub.2-Josiphos complex and the like, and examples of Cu catalysts include CuI, Cu(OAc).sub.2, Cu.sub.20, CuO, CuBr, CuCl, CuSO.sub.4, CuFe.sub.2O.sub.4, and the like, and a Cu catalyst is preferable, and Cu.sub.2O is more preferable.
[0163] Examples of solvents for the amination reaction include solvents such as dimethyl

sulfoxide, N,N-dimethylformamide, N-methylpyrrolidone (NMP), 1,4-dioxane, acetonitrile, toluene, a mixed solvent thereof and the like, where N-methylpyrrolidone (NMP) is preferable.
[0164] A base may be present in the amination reaction, and examples of bases include bases such as potassium carbonate, potassium phosphate, cesium carbonate, N,N-diisopropylethylamine, triethylamine and the like.
[0165] The amination reaction is performed by seald tube heating using a sealed tube reactor (made of, for example, stainless steel, glass, or the like). When a heating reaction is performed, heating above a boiling point of a solvent or reagent used is generally not performed, and heating is performed in a closed system using a sealed tube reactor or the like when the reaction is performed at a temperature higher than a boiling point of a solvent or reagent used.
[0166] Examples of solvents that can be used when performing the amination reaction and their boiling points are as follows: dimethyl sulfoxide (boiling point 189° C.), N,N-dimethylformamide (boiling point 153° C.), N-methylpyrrolidone (NMP) (boiling point 202° C.), 1,4-dioxane (boiling point 101° C.), acetonitrile (boiling point 82° C.), and toluene (boiling point 110.6° C.). Furthermore, a boiling point of ammonia water is 37.7° C. for 25% ammonia water and 24.7° C. for 32% ammonia water.
[0167] A reaction temperature when performing the amination reaction can be appropriately selected from, for example, a reaction temperature within a range of 100° C. to 250° C., a range of 100° C. to 200° C., a range of 100° C. to 150° C., and the like. A reaction temperature is preferably within a range of 100° C. to 120° C.
[0168] In the amination reaction, when Cu.sub.2O is used, a usage amount of the metal catalyst is generally 0.1 to 1.0 molar equivalents, is preferably 0.2 to 0.8 molar equivalents, and is more preferably 0.5 to 0.7 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (A8).
[0169] In the amination reaction, a usage amount of the organic solvent is generally 0.1 to 30 times, and is preferably 0.5 to 20 times an amount of 1 g of the compound represented by Formula (A8).
[0170] In the amination reaction, a usage amount of the ammonia water is generally 1.0 to 50 times, is preferably 2.5 to 30 times, and is more preferably 2.5 to 3.5 times an amount of 1 g of the compound represented by Formula (A8).
[0171] Unless otherwise specified, a numerical value range described in the present specification also includes ±10% values of that values. For example, when the phrase “0.1 to 1.0 molar equivalents” is referred to, it means 0.1±0.01 to 1.0±0.1 molar equivalents, and when the phrase “0.1 to 30 times an amount . . . ” is referred to, it means 0.1±0.01 to 30 3 times.
<Step of Producing Compound Represented by Formula (I)>
[0172] The compound represented by Formula (I) is obtained by a condensation reaction of the compound represented by Formula (B) or a salt thereof and the compound represented by Formula (CA-1) while using DMT-MM as a condensation agent.
[0173] The condensation reaction may be performed in the presence of a solvent. Examples of solvents include solvents not involved in the reaction such as alcohol-based solvents such as methanol, ethanol, propanol, isopropanol, butanol and the like; ether-based solvents such as tetrahydrofuran, 1,4-dioxane, butyl ether and the like; and water, or a mixed solvent thereof, and alcohol-based solvents, water, or a mixed solvent thereof is preferable; methanol, ethanol, isopropanol, water, or a mixed solvent thereof is more preferable; methanol, ethanol, or isopropanol is even more preferable; and methanol or isopropanol is particularly preferable.
[0174] In the condensation reaction, a usage amount of the carboxylic acid compound represented by Formula (CA-1) is generally 0.5 to 2.0 molar equivalents, is preferably 0.5 to 1.5 molar equivalents, and is more preferably 0.7 to 1.25 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (B) or a salt thereof. As will be described later, the inventors of the present invention have found that use of DMT-MM for a condensation agent enables a selective condensation reaction of a carboxyl group of the compound represented by

Formula (CA-1) and an amino group of the compound represented by Formula (B), and that, therefore, it is not required to protect hydroxyl groups of the compound represented by Formula (B) in the condensation reaction.
[0175] In the condensation reaction, a salt of the compound represented by Formula (B) is preferably an HCl salt or an HBr salt.
[0176] In the condensation reaction, a usage amount of DMT-MM as a condensation agent is generally 1.0 to 2.0 molar equivalents, is preferably 1.1 to 1.8 molar equivalents, and is more preferably 1.2 to 1.5 molar equivalents, with respect to 1 molar equivalent of the compound represented by Formula (B) or a salt thereof.
[0177] When a salt of the compound represented by Formula (B) is used in the condensation reaction, a base may be added. Examples of bases include organic bases such as triethylamine, N,N-diisopropylethylamine, pyridine and the like; and inorganic bases such as lithium hydroxide (lithium hydroxide monohydrate), sodium hydroxide, potassium hydroxide, lithium carbonate, sodium carbonate, potassium carbonate and the like. Triethylamine, N,N-diisopropylethylamine, pyridine, sodium carbonate, or potassium carbonate is preferable, and triethylamine is more preferable.
[0178] An amount of base that can be added when the salt of the compound represented by Formula (B) is used in the condensation reaction is generally 1.0 to 2.5 molar equivalents, is preferably 1.05 to 2.3 molar equivalents, and is more preferably 1.05 to 2.1 molar equivalents, with respect to 1 molar equivalent of a salt of the compound represented by Formula (B).
[0179] In the condensation reaction, a usage amount of the solvent is generally 5.0 to 100 times, is preferably 5 to 40 times, and is more preferably 5 to 30 times an amount of 1 g of the compound represented by Formula (B) or a salt thereof.
[0180] A reaction temperature when performing the condensation reaction can be appropriately selected from a reaction temperature within, for example, a range of −78° C. to a temperature at which the solvent is refluxed, a range of −78° C. to room temperature, a range of 0° C. to a temperature at which the solvent is refluxed, a range of 0° C. to room temperature, and the like. A reaction temperature is preferably within a range of 0° C. to room temperature.
[0181] 8-amino-1,2,3,4-tetrahydronaphthalen-2-ol [CAS No. 624729-66-4] represented by Formula (A) in the above-described aspect [1] can be produced by selectively reducing a naphthalene ring using 8-aminonaphthalen-2-ol (Formula (SM-1)) as a starting material according to a production method known from a literature, for example, a production method below which is disclosed in WO 2009/050289 (Patent Literature 6).
##STR00040##
[0182] (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid [CAS No. 920334-15-2]represented by Formula (CA-1) in the above-described aspects [7] to [11] and the above-described aspects [17] to [20] can be produced by performing several steps using 3-hydroxybenzotrifluoride (Formula (CA-SM)) as a starting material according to a production method known from a literature, for example, a production method below which is disclosed in WO 2007/010383 (Patent Literature 1).
##STR00041##
[0183] For the compound represented by Formula (SM8) in the above-described aspects [13], [15], [17], and [18], a commercially available compound can be used. Alternatively, it can be obtained according to a production method known from a literature using a commercially available compound.
[0184] In the compound represented by Formula (SM8), the compound in which X=fluorine atom (Formula (SM8-FL)) can be produced according to, for example, a production method of (Scheme 4-3) below which is disclosed in European Patent Application Publication No. 343830.
##STR00042##
[0185] In the compound represented by Formula (SM8), the compound in which X=chlorine atom

(Formula (SM8-CL)) can be produced according to, for example, a production method of (Scheme 4-4) below which is disclosed in European Patent Application Publication No. 343830.
##STR00043##
[0186] In the compound represented by Formula (SM8), the compound in which X=bromine atom (Formula (SM8-BR)) can be produced according to, for example, a production method of (Scheme 4-5) below which is disclosed in Journal of Medicinal Chemistry, 36(17), p2485-93, 1993 and European Journal of Medicinal Chemistry (1993), 28(9), p693-701.
##STR00044##
[0187] In Formula (SM8), the compound in which X=iodine atom (Formula (SM8-ID)) can be produced according to the production methods for Formula (SM8-FL), Formula (SM8-CL), and Formula (SM8-BR) (Scheme 4-6).
##STR00045##
[0188] A raw material compound of each of the steps in the production method can be used in the next step as a reaction solution itself or as a crude product. Furthermore, the raw material compound can also be isolated from a reaction mixture according to a conventional method, and it can be easily purified by a known method, for example, a separation methods such as extraction, concentration, neutralization, filtration, distillation, recrystallization, chromatography and the like.
[0189] When a mixed solvent is used in the above-described reactions, it can be used by mixing two or more kinds of solvents in an appropriate ratio, for example, in a ratio of 1:1 to 1:10 as a volume ratio or a weight ratio.
[0190] Unless otherwise specified, a reaction time for each of the steps in the production method is not limited as long as it is a time that enables the reaction to proceed sufficiently. For example, a reaction time may be any of 0.1 hours, 0.5 hours, 1 hour, 1.5 hours, 2 hours, 3 hours, 4 hours, 5 hours, 10 hours, 12 hours, 18 hours, 24 hours, 36 hours, 48 hours, 60 hours, 72 hours, or 115 hours, and it may be a time within a range of the lower limit value and the upper limit value of these times.
[0191] Regarding the reaction temperature, a temperature when the phrase “range of −78° C. to a temperature at which the solvent is refluxed” is referred to means a temperature within a range of −78° C. to a temperature at which the solvent (or a mixed solvent) used for the reaction is refluxed. For example, when methanol is used as the solvent, the phrase “−78° C. to a temperature at which the solvent is refluxed” means a temperature within a range of −78° C. to a temperature at which methanol is refluxed.
[0192] The same applies to when the phrase “0° C. to a temperature at which the solvent is refluxed” is referred to, and it means a temperature within a range of 0° C. to a temperature at which the solvent (or a mixed solvent) used for the reaction is refluxed. A lower limit value of the temperature is, for example, −78° C. or 0° C. as described above, but it also may be other temperatures such as 20° C., 23° C., 25° C., 40° C., 50° C., 70° C., 80° C., 90° C., 100° C., 150° C. and the like.
[0193] Regarding the reaction temperature, the lower limit value and the upper limit value of the reaction temperature may be, for example, ±1° C., ±2° C., ±3° C., ±4° C., and ±5° C. of the respective temperatures.
[0194] Unless otherwise specified, in the production method of the present specification, “room temperature” means a temperature of a laboratory, an experimental laboratory, or the like, and “room temperature” in examples of the present specification generally indicates a temperature from about 1° C. to about 30° C. (defined by the Japanese Pharmacopoeia). It preferably indicates a temperature of generally from about 5° C. to about 30° C., more preferably indicates a temperature of generally from about 15° C. to about 25° C., and even more preferably indicates a temperature of 20° C.±3° C.
[0195] The compounds in the present specification may form an acid addition salt depending on the type of substituent. Such a salt is not particularly limited as long as it is a pharmaceutically

acceptable salt, and examples thereof include a salt of an inorganic acid, a salt of an organic acid, and the like. Preferred examples of salts of inorganic acids include salts of hydrochloric acid, hydrobromic acid, hydriodic acid, nitric acid, sulfuric acid, phosphoric acid, and the like. Preferred examples of salts of organic acids include salts of aliphatic monocarboxylic acids such as formic acid, acetic acid, trifluoroacetic acid, propionic acid, butyric acid, valeric acid, enanthic acid, capric acid, myristic acid, palmitic acid, stearic acid, lactic acid, sorbic acid, mandelic acid and the like; salts of aliphatic dicarboxylic acids such as oxalic acid, malonic acid, succinic acid, fumaric acid, maleic acid, malic acid, tartaric acid and the like; salts of aliphatic tricarboxylic acids such as citric acid and the like; salts of aromatic monocarboxylic acids such as benzoic acid, salicylic acid and the like; salts of aromatic dicarboxylic acids such as phthalic acid and the like; salts of organic carboxylic acids such as cinnamic acid, glycolic acid, pyruvic acid, oxylic acid, salicylic acid, N-acetylcysteine and the like; salts of organic sulfonic acids such as methanesulfonic acid, benzenesulfonic acid, p-toluenesulfonic acid and the like; and acid addition salts of acidic amino acids such as aspartic acid, glutamic acid and the like.

[0196] The salt described above can be obtained according to a conventional method, for example, by mixing a solution containing an appropriate amount of an acid with the compound described in the present specification to form desired salts, and then fractionating the salts and collecting them by filtration; or by distilling off the mixed solvent. Furthermore, the compound in the present specification or a salt thereof can form a solvate with a solvent such as water, ethanol, glycerol and the like. As a review article on salts, Handbook of Pharmaceutical Salts: Properties, Selection, and Use. Stahl & Wermuth (Wiley-VCH, 2002) has been published, and this book includes detailed description.

[0197] As shown in (Scheme 5) below, using the compound represented by Formula (A) as a starting material, the compound represented by Formula (B) or a salt thereof can be produced via the compounds of Formulas (A-5), (A-6), and (A-7).

##STR00046##

[0198] Furthermore, as shown in (Scheme 6) below, the compound represented by Formula (B) or a salt thereof can be produced by a method according to (Scheme 5) described above by changing a protecting group of an amino group of the compound represented by Formula (A) to a protecting group, which is other than a tert-butoxycarbonyl group, for example, a protecting group P.sup.1 such as carbamate-based protecting groups such as a methoxycarbonyl group, an ethoxycarbonyl group, a benzyloxycarbonyl group, a 2,2,2-trichloroethoxycarbonyl group, a 9-fluorenylmethyloxycarbonyl group, an allyloxycarbonyl group and the like; sulfonyl-based protecting groups such as a methanesulfonyl group, an ethanesulfonyl group, a benzenesulfonyl group, a tosyl group, a nitrobenzenesulfonyl group and the like; and alkylcarbonyl-based or arylcarbonyl-based protecting groups such as an acetyl group, an ethylcarbonyl group, a trifluoroacetyl group, a benzoyl group and the like.

##STR00047##

[0199] Conditions for protection of the compound represented by Formula (A) by the protecting group P.sup.1 or deprotection of the protecting group P.sup.1 of the compound represented by Formula (A-7p) can be selected according to the type of protecting group P.sup.1 by a method known from a literature, for example, a protection and deprotection method disclosed in the book, “Protective Groups in Organic Synthesis, 4th Edition, 2007, John Wiley & Sons, Greene et al.”

[0200] As shown in (Scheme 7) below, using the compound represented by Formula (SM8) as a starting material, the compound represented by Formula (B) can be produced via the compound represented by Formula (A8).

##STR00048##

[0201] Furthermore, as shown in (Scheme 8) below, using the compound represented by Formula (SM8-BR) as a starting material, the compound represented by Formula (B) can be produced via the compound represented by Formula (A8-BR).

##STR00049##
[0202] As shown in (Scheme 9) below, using the compound represented by Formula (A) as a starting material, the compound represented by Formula (I) can be produced via the compound represented by Formula (B). In (Scheme 9), the compound represented by Formula (B-HA) represents a salt of an acid HA of the compound represented by Formula (B), where HA represents an acid.
##STR00050##
[0203] Furthermore, as shown in (Scheme 10) below, using the compound represented by Formula (A) as a starting material, the compound represented by Formula (I) can be produced via the compound represented by Formula (B). The definition of a substituent P.sup.1 in (Scheme 10) is the same as the definition in (Scheme 6) described above. In (Scheme 10), the compound represented by Formula (B-HA) represents a salt of an acid HA of the compound represented by Formula (B), where HA represents an acid.
##STR00051##
[0204] Furthermore, as shown in (Scheme 11) below, using the compound represented by Formula (SM8) as a starting material, the compound represented by Formula (I) can be produced via the compound represented by Formula (B). In (Scheme 11), the compound represented by Formula (B-HA) represents a salt of an acid HA of the compound represented by Formula (B), where HA represents an acid.
##STR00052##
[0205] Furthermore, as shown in (Scheme 12) below, using the compound represented by Formula (SM8-BR) as a starting material, the compound represented by Formula (I) can be produced via the compound represented by Formula (B). In (Scheme 12), the compound represented by Formula (B-HA) represents a salt of an acid HA of the compound represented by Formula (B), where HA represents an acid.
##STR00053##
[0206] In the present specification, the compounds of Formula (A), Formula (A-5), and Formula (A-5p) which are racemates include an (R) form and an (S) form. This means that, for example, Formula (A-5) includes Formula (A-5S) and Formula (A-5R) (=Formula (A-7)).
##STR00054##
[Asymmetric Reduction of Ketones]
[0207] Various reactions are known as a method for converting a keto group in a molecule to a chiral alcohol group. For example, there is a method in which a keto group is converted to a racemic alcohol group using a reducing agent (sodium borohydride, lithium aluminum hydride (LAH), borane-tetrahydrofuran (BH.sub.3-THF), and the like), and thereafter, induced to a chiral alcohol group by a method such as a fractional recrystallization method (a method in which a crystalline diastereomer is obtained by ionic bonding of an optical resolution agent to a racemate, and this crystalline diastereomer is fractionated by recrystallization and neutralized if desired to obtain a free chiral compound), a diastereomer method (refer to WO 2009/055749), and a chiral column method (refer to WO 2009/050289).
[0208] Furthermore, the following reactions are known: an asymmetric reductive reaction using a transition metal catalyst (for example, Ru, Rh and the like) (WO 2009/050289; Organometallics 10, p500-, 1991; and the like), an asymmetric reductive reaction in which Al(CH.sub.3).sub.3 and BINOL as a ligand are combined (Angew. Chem. Int. Ed., 41, p1020-, 2002), an asymmetric reductive reaction using a chiral Ru (BINAP) catalyst (J. Am. Chem. Soc. 110, p629-, 1988), an asymmetric reductive reaction using oxazaborolidine (J. Am. Chem. Soc. 109, p5551-, 1987), an asymmetric reductive reaction using a biocatalyst (yeast, fungus, mold, enzyme, and the like) (refer to Table 1), and the like.
[0209] In some aspects, the asymmetric reduction is preferably performed using a biocatalyst. The asymmetric reduction using a biocatalyst has advantages in that not only it has high

stereoselectivity, an organic solvent and/or water can be used as a reaction solvent, the reaction proceeds under mild conditions (normal temperature, normal pressure), and it is cheaper than a chemical catalyst, and the like, but alos it is a reaction that has been attracting attention in recent years for being an environmentally friendly reaction because an amount of waste after the reaction can be reduced, and is also a useful reaction for easily obtaining a chiral compound.

[0210] Generally, in the asymmetric reductive reaction using an enzyme, a chemical yield (%) and an optically active yield (ee %) of a chiral compound to be obtained vary depending on reaction specificity (selectivity for type of enzyme-specific reaction), substrate specificity (selectivity for type of substrate), and reaction conditions (reaction temperature, pH, solvent, reaction time, and the like). Many enzymes have very high reaction specificity, and reactions catalyzed by one enzyme are limited, but there are various enzymes, i.e., enzymes with higher substrate specificity or enzymes with lower substrate specificity. Accordingly, for example, when a keto group is asymmetrically reduced to a chiral alcohol group, even if an enzyme from which a favorable chemical yield and optically active yield are obtained from compounds having a similar structure to that of a substrate (ketone compound) to be used is selected and an enzymatic reaction is performed under the same conditions, a desired chiral alcohol compound may not be obtained at the same chemical yield and optically active yield.

[0211] For example, biocatalysts, which can selectively reduce a keto group of P-tetralone [CAS number: 530-93-8] to a chiral alcohol, shown in Table 1 are known.

TABLE-US-00001 TABLE 1 Biocatalyst Origin Disclosure document Enzyme Magnaporthe grisea expressed in Angewandte Chemie, International *Escherichia coli* BL21 Edition, 51(11), p2643-2646, 2012 whole cells of Kluyveromyces Tetrahedron Asymmetry, 22(23), p1985- marxianus CBS 6556 1993, 2011 Thermoanaerobacter ethanolicus Practical Methods for Biocatalysis and (TeSADH) Biotransformations, p284-287, 2010 whole cells of Didymosphaeria Journal of Industrial Microbiology & igniaria KCH6670 Biotechnology, 37(11), p1121-1130, 2010 Paracoccus pantotrophus DSM ChemSusChem, 1(5), p431-436, 2008 11072 overexpressed in *E. coli Ralstonia* sp. DSM 6428 Journal of Organic Chemistry, 73(15), (RasADH) p6003-6005, 2008 Sphingobium yanoikuyae Organic Letters, 10(11), p2155-2158, 2008 Thermoanaerobacter ethanolicus WO 2008/013949 expressed in *Escherichia coli* Thermoanaerobacter ethanolicus Angewandte Chemie, International W110A Edition, 46(17), p3091-3094, 2007 Rhodococcus ruber DSM 44541 Organic Letters, 9(11), p2163-2166, 2007 W110A TESADH. Journal of Organic Chemistry, 72(1), p30-34, 2007 *Lactobacillus kefir*. sp Advanced Synthesis & Catalysis, 350(14 + 15), p2322-2328, 2008 Yeast Candida viswanathii Biocatalysis and Biotransformation, 31(3), p123-131, 2013 Fungus Absidia cylindrospora KCh 336 Current Microbiology, 65(2), p189-194, 2012 Lyophilised cells of *Comamonas* Tetrahedron: Asymmetry, 19(16), sp. p1954-1958, 2008 Rhodococcus ruber DSM 44541 Journal of Organic Chemistry, 68(2), p402-406, 2003 Saccharomyces montanus cbs Tetrahedron: Asymmetry, 7(10), p2983- 6771 2996, 1996 Mold Aspergillus ochraceus atcc 1009. Tetrahedron: Asymmetry, 7(10), p2983- Mucor racemosus 2996, 1996 rhizopus arrhizus atcc 11145 Cell Lycoperiscumesculentum International Journal of ChemTech culture (tomato) Research, 4(1), p203-207, 2012 solution Plant Daucas Carota root ext U.S. Patent Application Publication No. 2004-0082043 Coryneum betulinum KCh 6534 Current Microbiology, 65(2), p189-194, 2012 Fusarium culmorum Biocatalysis and Biotransformation, 27(3), p179-185, 2009

[Flow Chemistry]

[0212] For synthetic reactions, there are generally a flow method (flow chemistry) and a batch method. The flow chemistry is a continuous synthesis method using a reaction device that sends a liquid from a vessel containing two or more different kinds of solutions (for example, raw material+solvent, reagent+solvent, and the like) through a tube to a reactor, and then to a recovery drum, at a constant flow rate using a pump.

[0213] The flow chemistry can be used when converting the compound represented by Formula (A-

5) to the compound represented by Formula (A-6) by an oxidation reaction. FIG. **1** shows an example of a reaction device used in the flow chemistry. The reaction device shown in FIG. **1** has nitrogen inlets (L**1**, L**2**, L**3**, L**4**); a vessel (M**1**) containing a raw material, TEMPO, and dichloromethane; a vessel (M**2**) containing KBr, NaHCO.sub.3, and water; a vessel (M**3**) containing 5.0 wt % NaClO; pumps (P**1**, P**2**, P**3**); pre-cooling tubes (T**1**, T**2**, T**3**); stirrers (S**1**, S**2**, S**3**); and reactor (R**1**, R**2**, R**3**).

[0214] The reaction device of FIG. **1** is used as follows, for example. First, a raw material (the compound represented by Formula (A-5)), TEMPO, and dichloromethane are put in the vessel M**1**, KBr, sodium hydrogen carbonate, and water are put in the vessel M**2**, and 5.0 wt % NaClO is put in the vessel M**3**. While flowing nitrogen gas from the respective nitrogen inlets L**1**, L**2**, L**3**, L**4**, the reagents are flowed from the respective vessels M**1**, M**2**, M**3** at a predetermined flow rate using the respective pumps P**1**, P**2**, P**3**, then are passed through the respective pre-cooling tubes T**1**, T**2**, T**3**, then are sequentially passed through the reactor R**1**, the reactor R**2**, and the reactor R**3**, and thereby are poured into a recovery drum CD. Then, a target product (the compound represented by Formula (A-6)) is obtained from the recovery drum CD. The flow chemistry can also be applied to reactions which is difficult to keep safety by a normal batch method (refer to a review article on flow chemistry ChemSusChem, 5(2), Special Issue; Flow Chemistry, p213-439, Feb. 13, 2012).

[0215] The batch method is a general synthetic reaction and is a method of purifying a product obtained after performing a reaction using a reactor. The batch method has the advantage in that a compound can be synthesized in several steps. In the flow method (flow chemistry), a reaction is performed in flow mode using, for example, a continuous stirred tank reactor (CSTR) as a reaction device. In the flow method, because the reaction can be performed in a small reactor, a reaction efficiency is high and reaction conditions can be precisely controlled, so a target product can be stably supplied.

[Amination Reaction]A method (amination reaction) of converting a halogen atom of a halogenated aryl to an amino group can be performed in the presence of a metal catalyst and in the presence or absence of a ligand using, as a nitrogen source, a compound represented by NHR.sup.AR.sup.B (where R.sup.A and R.sup.B each independently represent a hydrogen atom, or a substituent such as a methyl group, an ethyl group, a benzyl group, and the like), R.sup.CCONH.sub.2 (where R.sup.C independently represents a substituent such as a methyl group, an ethyl group, a benzyl group, a methoxy group, an ethoxy group, a tert-butoxy group, a benzyloxy group, and the like), or the like.

[0216] For an amination reaction of a halogenated aryl using ammonia as a nitrogen source, for example, the following method using a metal catalyst is known as a method known from a literature, but a method is not limited thereto. Pd.sub.2(dba).sub.3 (J. Am. Chem. Soc., 129(34), p10354-10355, 2007), PdCl.sub.2-Josiphos complex (J. Am. Chem. Soc., 128(31), pi0028-10029, 2006), CuI (Chem. Commun., 26, p3052-3054, 2008; J. Org. Chem., 74(12), p4542-4546, 2009), Cu(OAc).sub.2 (Angew. Chem. Int. Ed., 48(2), p337-339, 2009), Cu.sub.2O (Ukrainskii Khimiche skii Zhurnal (Russian Edition), 53(12), P1299-302, 1987).

[0217] For example, for an amination reaction to 8-halo-1,2,3,4-tetrahydronaphthalen-2-ol in which a secondary alcohol is present in a molecule, an amination reaction using Pd.sub.2(dba).sub.3 as a metal catalyst and tert-butyl carbamate as a nitrogen source is known, but examples using other metal catalysts are not known.

[0218] In some aspects, the amination reaction is preferably a reaction that enables direct introduction of an amino group by ammonia. Alternatively, it is also possible to introduce an amino group by deprotecting a protecting group after substitution with, for example, a protected amino compound such as NHR.sup.A1R.sup.B1 (where R.sup.Al is a hydrogen atom, and R.sup.B1 represents a protecting group of an amino group such as a benzyl group, a 4-methoxybenzyl, and the like), and R.sup.CCONH.sub.2 (where R.sup.C independently represents a substituent such as a methyl group, an ethyl group, a benzyl group, a methoxy group, an ethoxy group, a tert-butoxy

group, a benzyloxy group, and the like). However, since the amination reaction using a protected amino compound requires a step of deprotecting a protecting group, the reaction that enables direct introduction of an amino group by ammonia is preferable when considering large-scale synthesis or industrial production.

[Condensation Reaction]

[0219] In general, regarding a condensation reaction of a compound having a carboxyl group and a compound having an amino group, an amide bond can be formed by performing a condensation reaction using, for example, a condensation agent such as 1,3-dicyclohexylcarbodiimide (DCC), 1-ethyl-3-(3′-dimethylaminopropyl)carbodiimide hydrochloride (WSC-HCl), benzotriazol-1-yloxytris(dimethylamino)phosphonium hexafluorophosphate (BOP reagent), bis(2-oxo-3-oxazolidinyl)phosphinic chloride (BOP-C1), 2-chloro-1,3-dimethylimidazolinium hexafluorophosphate (CIP), and the like (refer to, for example, Experimental Chemistry Course 22, 4th Edition, Organic Synthesis IV: Acids, Amino Acids, Peptides, pp. 193-309, 1992, Maruzen; and the like).

[0220] As a result of the examination on the condensation agent, the inventors of the present invention have found that the compound represented by Formula (I) can be easily produced in a high yield by using particularly DMT-MM as a condensation agent in a condensation reaction of the compound represented by Formula (B) which has both a hydroxyl group and an anilinic amino group and heterocyclidene acetic acid represented by Formula (CA-1) which has a carboxyl group.

[0221] All publications cited in the present specification, such as prior art documents, unexamined patent publications, patent publications, and other patent documents, are incorporated in the present specification by reference in their entirety. The present specification includes disclosures of the scope of claims, specifications, and drawings of Chinese Patent Application No. 201910783254.8 (filed on Aug. 23, 2019), International Patent Application No. PCT/JP2019/036451 (filed on Sep. 18, 2019), and Chinese Patent Application No. 202010355546.4 (filed on Apr. 29, 2020), which are the basis for claiming priority of the present application.

EXAMPLES

[0222] Hereinafter, the present invention will be specifically described with reference to examples, but the present invention is not limited thereto.

[0223] Bruker AVANCE III 400 MHz NMR spectrometer (equipped with a 5 mm Bruker PABBO Z-gradient probe and TOPSPIN 3.5 software) was used for measurement of nuclear magnetic resonance (NMR) spectra of the compounds represented by Formula (A-5), Formula (A-6), Formula (A-7), and Formula (B). Furthermore, JEOL JNM-LA300 FT-NMR (JEOL Ltd.) was used for measurement of nuclear magnetic resonance (NMR) spectra of a bromate salt of the compound represented by Formula (B) and the compound represented by Formula (I).

[0224] The compounds represented by Formula (A-5), Formula (A-6), Formula (A-7), and Formula (B) were measured by high-performance liquid chromatography (HPLC) under the following conditions.

TABLE-US-00002 TABLE 2 [HPLC analysis conditions for compound represented by Formula (A-5), Formula (A-6), and Formula (A-7)] Measuring Agilent 1260 HPLC with UV detector or equivalent instrument Column Waters Xbridge C18, (150 mm × 4.6 mm, 3.5 μm) (PN: 186003034) Measurement 210 nm wavelength Column 40° C. temperature Flow rate 1.0 mL/min Injection 5 μL capacity Sample Compound represented by Formula (A-5) or Formula concentration (A-7): 0.2 mg/mL, Compound represented by Formula (A-6): 0.25 mg/mL Performance time 20 minutes Data collection 20 minutes time Dilution agent CH.sub.3CN Mobile phase A Aqueous solution of 5 mM NH.sub.4Ac (Preparation example: 770 mg of NH.sub.4Ac is accurately weighed in and thoroughly mixed with 2,000 mL of pure water, and the mixture is degassed by ultrasonic waves) Mobile phase B CH.sub.3CN Mobile phase A Mobile phase B Time (min) (%) (%) Gradient Initial time 95 5 program 12.00 10 90 14.00 10 90 15.00 95 5 20.00 95 5 Rebalancing time: 5 minutes

TABLE-US-00003 TABLE 3 [Retention time (RT) of each compound] Relative RT retention time

Compound (min) (RRT) Ethyl acetate 5.8 0.62 Compound represented by Formula (A) 6.2 0.67 Dichloromethane 7.0 0.75 Compound represented by Formula (A-5) 9.3 1.00 or Formula (A-7) TEMPO 9.5 1.02 Compound represented by Formula (A-6) 9.8 1.05 Toluene 11.0 1.18
TABLE-US-00004 TABLE 4 [HPLC analysis conditions for compound represented by Formula (B)] Measuring Shimadzu LC-20A HPLC with UV detector instrument Column ACE 3 C18 (150 mm × 4.6 mm, 3 μm) Measurement 213 nm wavelength Column 35° C. temperature Flow rate 1.0 mL/min Sample Compound represented by Formula B: 0.1 mg/mL, concentration Hydrochloride salt of compound represented by Formula B: 0.12 mg/mL Injection 5 μL capacity Mobile phase Mobile phase A: aqueous solution of 5 mM NH.sub.4Ac Mobile phase B: CH.sub.3CN Mobile phase A Mobile phase B Time (min) (%) (%) Gradient 0.01 95 5 program 4.00 70 30 10.0 10 90 11.00 10 90 12.00 95 5 16.0 stop stop Performance 16 minutes time Dilution MeOH agent
TABLE-US-00005 TABLE 5 [Retention time (RT) for each compound] Relative RT retention time Compound (min) (RRT) Formula (B) 7.0 1.00 Formula (A-7) 9.6 1.36 Toluene 11.0 1.57
TABLE-US-00006 TABLE 6 [Chiral analysis conditions by HPLC for compound represented by Formula (A-7)] Measuring Shimadzu LC-20A HPLC with UV detector or instrument equivalent Column Daicel Chiralpak AD-H (250 × 4.6 mm, 5.0 μm) column, PN: 19325 Measurement 230 nm wavelength Column 35° C. temperature Flow rate 1.0 mL/min Injection 5 μL capacity Sample 2.5 mg/mL concentration Data 20 min collection time Performance time 20 min Dilution agent EtOH Mobile phase Mixed solution of 0.1% diethylamine n- hexane/ethanol (9/1, v/v) (Preparation example: 900 mL of n-hexane and 100 mL of ethanol are thoroughly mixed, and next, 1 mL of diethylamine is added to and mixed with the mixed solution of n-hexane and ethanol) Time (min) Formula (A-7) (%) Isocratic 0.00 100 program 20.00 100
TABLE-US-00007 TABLE 7 [Retention time (RT) for each compound] Relative RT retention time Compound (min) (RRT) Compound represented by Formula (A-7) 8.1 1.00 Enantiomer of compound represented by 9.9 1.22 Formula (A-7)
[0225] Furthermore, a liquid chromatography-mass spectrometry (LC-Mass) spectrum of the bromate salt of the compound represented by Formula (B) and the compound represented by Formula (I) was measured by the following method. [UPLC] Waters AQUITY UPLC system and BEH C18 column (2.1 mm×50 mm, 1.7 μm) (Waters) were used, and a mobile phase and gradient conditions of acetonitrile:aqueous solution of 0.05% trifluoroacetic acid=5:95 (0 minutes) to 95:5 (1.0 minute) to 95:5 (1.6 minutes) to 5:95 (2.0 minutes) were used.
[0226] In .sup.1H-NMR data, s means singlet, d means doublet, t means triplet, q means quartet, m means multiplet, brs means broad as the pattern of NMR signals, J means coupling constant, Hz means Hertz, DMSO-d.sub.6 is deuterated dimethyl sulfoxide, and CDCl.sub.3 means deuterated chloroform. In .sup.1H-NMR data, signals, which cannot be confirmed because of being broadband signals, such as protons of a hydroxyl group (OH), an amino group (NH.sub.2), and an amide group (CONH), are not described in the data.
[0227] In LC-Mass data, M means molecular weight, RT means retention time, and [M+H].sup.+means molecular ion peak.
(Examples 1a to 1d) Synthesis of tert-butyl(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (A-5)
##STR00055##
Example 1a
[0228] Di-tert-butyl dicarbonate (Boc.sub.2O) (0.74 g) was added to a solution of the compound represented by Formula A (produced according to a production method disclosed in WO 2009/050289) (0.5 g) and sodium hydrogen carbonate (0.154 g) in 1,4-dioxane (5 mL)-water (5 mL), and the mixture was stirred at a reaction temperature of 20° C. to 30° C. for 22 hours. Sodium hydrogen carbonate (0.104 g) was further added to the mixture, and the mixture was stirred at a reaction temperature of 20° C. to 30° C. for 18 hours. Di-tert-butyl dicarbonate (0.15 g) was further added to the mixture, and the mixture was stirred at a reaction temperature of 20° C. to 30° C. for 5

hours. Di-tert-butyl dicarbonate (0.15 g) was further added to the mixture, and the mixture was stirred at a reaction temperature of 20° C. to 30° C. for 16 hours. Di-tert-butyl dicarbonate (0.1 g) was further added to the mixture, and the mixture was further stirred at a reaction temperature of 20° C. to 30° C. for 1 hour. Ethyl acetate was added to the reaction solution, and the organic layer was fractionated. The aqueous layer was washed with ethyl acetate, and the organic layer was combined with the previously obtained organic layer, and then washed with brine. The organic layer was concentrated under reduced pressure, and the obtained residue was solidified with dichloromethane and n-heptane to obtain the title compound (0.46 g).

Example 1b

[0229] Di-tert-butyl dicarbonate (Boc.sub.2O) (1.61 g) was added to a solution of the compound represented by Formula A (produced according to a production method disclosed in WO 2009/050289) (1.0 g) and sodium hydrogen carbonate (1.55 g) in tetrahydrofuran (10 mL)-water (10 mL), and the mixture was stirred at a reaction temperature of 45° C. to 55° C. for 17 hours. Di-tert-butyl dicarbonate (0.13 g) was further added to the mixture, and the mixture was stirred at a reaction temperature of 45° C. to 55° C. for 2 hours. After cooling the reaction solution to room temperature, methyl tert-butyl ether (MTBE) was added to the reaction solution, and a pH was adjusted to 5 to 6 with a 10 w/v % citric acid solution, then the organic layer was fractionated. The aqueous layer was extracted with methyl tert-butyl ether, and the organic layer was combined with the previously obtained organic layer, and then washed with water and brine. The organic layer was concentrated under reduced pressure, and the obtained residue was solidified with dichloromethane and n-heptane to obtain the title compound (1.34 g).

Example 1c

[0230] Di-tert-butyl dicarbonate (Boc.sub.2O) (17.4 g) was added to a solution of the compound represented by Formula A (produced according to a production method disclosed in WO 2009/050289) (10 g) and sodium hydrogen carbonate (15.5 g) in tetrahydrofuran (100 mL)-water (100 mL), and the mixture was stirred at a reaction temperature of 45° C. to 55° C. for 17 hours. Di-tert-butyl dicarbonate (1.3 g) was further added to the mixture, and the mixture was stirred at a reaction temperature of 45° C. to 55° C. for 2 hours. Di-tert-butyl dicarbonate (1.3 g) was further added to the mixture, and the mixture was further stirred at a reaction temperature of 45° C. to 55° C. for 1 hour. After cooling the reaction solution to room temperature, methyl tert-butyl ether (MTBE) was added to the reaction solution, and a pH was adjusted to 5 to 6 with a 10% citric acid solution, then the organic layer was fractionated. The aqueous layer was extracted with methyl tert-butyl ether, and the organic layer was combined with the previously obtained organic layer, and then washed with water and brine. The organic layer was concentrated under reduced pressure, and the obtained residue was solidified with dichloromethane and n-heptane to obtain the title compound (15.1 g).

Example 1d

[0231] A solution of the compound represented by Formula A (produced according to a production method disclosed in WO 2009/050289) (218.5 g) in tetrahydrofuran (1.9 L) was adjusted to a temperature of 20° C. to 30° C., and an aqueous solution of sodium hydrogen carbonate (319 g (3.2 eq) of sodium carbonate, and 1.9 L of water) was added to the solution over 10 minutes at a temperature of 20° C. to 30° C. The temperature of the above mixed solution was set to 0° C. to 10° C., and di-tert-butyl dicarbonate (413 g) was added to the mixed solution over 15 minutes while maintaining the same temperature. A reaction temperature was set to 45° C. to 55° C., and the mixed solution was stirred at the same temperature for 18 hours. After cooling the reaction temperature to 20° C. to 30° C., methyl tert-butyl ether (1.9 L) was added to the reaction solution, and the mixed solution was stirred at 20° C. to 30° C. for 10 minutes. A 10% citric acid solution (2.5 L) was added to the mixed solution, and the organic layer was fractionated. The aqueous layer was extracted with methyl tert-butyl ether (1 L x 2 times), and the organic layer was combined with the previously obtained organic layer, and then washed with water (1 L x 2 times). After

concentrating the organic layer under reduced pressure until it was about 500 mL, an operation of adding dichloromethane (1 L) and concentrate the organic layer under reduced pressure until the organic layer was about 500 mL was performed twice, then n-heptane (1 L) was added and the organic layer was concentrated under reduced pressure until the organic layer was about 500 mL, n-heptane (800 L) was added and the organic layer was concentrated under reduced pressure until the organic layer was about 600 mL, and dichloromethane (300 mL) and n-heptane (600 mL) were added and the organic layer was concentrated under reduced pressure until the organic layer was about 600 mL, thendichloromethane (1 L) was added, and activated carbon (21 g) was added thereto, and the mixed solution was stirred at 20° C. to 30° C. for 2 hours. Then, the mixed solution was filtered, and the filtrate was concentrated under reduced pressure until it was about 500 mL, then dichloromethane (800 mL) was added thereto, and the solution was concentrated under reduced pressure until it was about 500 mL. Dichloromethane (800 mL) was added and the solution was filtered to obtain a solid. The obtained solid was dried at 35° C. for 15 hours to obtain the title compound (303.3 g) as a grayish-black solid.

[Data of Physical Properties of Compound Represented by Formula (A-5)]

[0232] (.sup.1H NMR, 400 MHz, manufacturer: Bruker, DMSO-d.sub.6, δ ppm) 8.36 (s, 1H), 7.09 (d, 1H, J=7 Hz), 7.03 (t, 1H, J=7 Hz), 6.87 (d, 1H, J=7 Hz), 4.78 (d, 1H, J=4 Hz), 3.90-3.84 (m, 1H), 2.89-2.81 (m, 2H), 2.75-2.65 (m, 1H), 2.42 (dd, 1H, J=7 Hz, 17 Hz), 1.90-1.80 (m, 1H), 1.62-1.53 (m, 1H), 1.46 (s, 9H)

(Examples 2a to 2f) Synthesis of tert-butyl(7-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (A-6)

##STR00056##

Example 2a

[0233] Using tert-butyl (R)-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (Formula (A-7)) (0.5 g) obtained from (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol in the same manner as in the methods of (Examples 1a to 1d), an oxidation reaction was performed under conditions of reagents shown in the following table, in a solvent (dichloromethane (12.5 mL)-water (7.5 mL)) at a reaction temperature (0° C. to 5° C.), and it was confirmed that the title compound was obtained (IPC purity using HPLC (IPC=in process control)).

TABLE-US-00008 TABLE 8 Reagent IPC purity A6 (%) 10% Reaction time TEMPO NaHCO.sub.3 KBr NaClO 10 30 60 18 No. (eq) (eq) (eq) (eq) (min) (min) (min) (h) 1 0.05 4 0.05 2 35.6 50.6 55.7 61.4 2 0.275 3 0.125 1.7 87.0 87.9 88.9 78.9 3 0.5 2 0.05 2 78.0 89.2 88.9 77.5 4 0.05 2 0.2 2 30.5 47.0 55.9 58.3 5 0.05 4 0.2 1.4 27.6 36.6 38.1 37.2 6 0.5 4 0.2 2 87.2 91.1 91.5 88.4 7 0.5 4 0.05 1.4 68.8 72.7 72.5 69.9 8 0.275 3 0.125 1.7 78.3 79.0 79.7 81.4 9 0.05 2 0.05 1.4 25.7 42.4 34.3 56.5 10 0.5 2 0.2 1.4 64.7 69.9 49.8 66.8

Example 2b

[0234] Using tert-butyl (R)-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (Formula (A-7)) (0.5 g) obtained from (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol in the same manner as in the methods of (Examples 1a to 1d), an oxidation reaction was performed under conditions of reagents shown in the following table, at a reaction temperature (0° C. to 5° C.) to obtain the title compound (IPC purity using HPLC).

TABLE-US-00009 TABLE 9 Solvent Reagent Water: 15 times IPC purity A6 (%) 10% its volume Reaction time TEMPO NaHCO.sub.3 KBr NaClO Solvent: 10 times (min) No. (eq) (eq) (eq) (eq) its volume 10 30 60 11 0.5 4 0.05 2 Water Acetone 0 0 0.8 7.5 mL 5 mL 12 0.5 4 0.05 2 Water CH.sub.3CN 14.9 13.6 10.6 7.5 mL 5 mL

Example 2c

[0235] A solution of tert-butyl (R)-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (Formula (A-7)) (10 g) which was obtained in the same manner as in the methods of (Examples 1a to 1d) in dichloromethane (250 mL, 25 times its volume)-water (150 mL, 15 times its volume) was cooled to −2° C. to 2° C., and TEMPO (0.5 eq), KBr (0.2 eq), NaHCO.sub.3 (4.0 eq), and NaClO

((8.1%), 1.4 eq.) were added to the solution at the same temperature. When an IPC purity was immediately confirmed thereafter, it was confirmed that the reaction was completed with a purity of 95.5%. The reaction solution was worked up, and thereby the title compound was obtained (.sup.1H-NMR yield 77.1%).

Example 2d

[0236] TEMPO oxidation was performed in flow mode using a continuous stirred tank reactor (CSTR) shown in FIG. **1**. A solution (500 mL) of tert-butyl-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (Formula (A-5)) (25 g) obtained in the same manner as in the methods of (Examples 1a to 1d) and TEMPO (0.5 eq) in dichloromethane was added into a vessel M**1**, and KBr (0.05 eq), sodium hydrogen carbonate (4 eq), and water (375 mL) were added into a vessel M**2**, and 5.0 wt % NaClO (1.3 eq) was added into a vessel M**3**. While flowing nitrogen gas from the respective nitrogen inlets Li, L**2**, L**3**, and L**4**, the reagents were flowed from the respective vessels M**1**, M**2**, and M**3** at each flow rate of 13.67 mL/min, 9.83 mL/min, and 4.27 mL/min using the respective pumps P**1**, P**2**, and P**3**, then were passed through the respective pre-cooling tubes T**1**, T**2**, and T**3** (temperature 0° C. to 5° C., tube length: 2 m, tube diameter: 1/16 SS), then were sequentially passed through the reactor R**1**, the reactor R**2**, and the reactor R**3** (where each of the reactors 1, 2, and 3 had a capacity of 25 mL, and the respective reactors were cooled to 0° C. to 5° C.), and thereby were poured into a recovery drum CD (where a reaction time in each of the reactors was 0.9 minutes). A target product was obtained with an IPC purity of 96.5% of the reaction solution obtained from the recovery drum CD.

Example 2e

[0237] TEMPO oxidation was performed in flow mode using a continuous stirred tank reactor (CSTR) shown in FIG. **1**. Tert-butyl (R)-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (Formula (A-5)) (35 g) obtained in the same manner as in the methods of (Examples 1a to 1d), TEMPO (0.5 eq), and dichloromethane (700 mL) were added into a vessel M**1**, and KBr (0.05 eq), sodium hydrogen carbonate (4 eq), and water (525 mL) were added into a vessel M**2**, and 5.0 wt % NaClO (1.3 eq) was added into a vessel M**3**. While flowing nitrogen gas from the respective nitrogen inlets Li, L**2**, L**3**, and L**4**, the reagents were flowed from the respective vessels M**1**, M**2**, and M**3** at each flow rate of 13.67 mL/min, 9.83 mL/min, and 4.27 mL/min using the respective pumps P**1**, P**2**, and P**3**, then were passed through the respective pre-cooling tubes T**1**, T**2**, and T**3** (temperature 0° C. to 5° C., tube length: 2 m, tube diameter: 1/16 SS), then were sequentially passed through the reactor R**1**, the reactor R**2**, and the reactor R**3** (where each of the reactors 1, 2, and 3 had a capacity of 25 mL, and the respective reactors were cooled to 0° C. to 5° C.), and thereby were poured into a recovery drum CD (where a reaction time in each of the reactors was 0.9 minutes, and it required 47 minutes to complete the flow). An IPC purity of the reaction solution (850 g) obtained from the recovery drum CD was 95.0%. An aqueous Na.sub.2S.sub.2O.sub.4 solution (Na.sub.2S.sub.2O.sub.4: 10 g, water: 250 mL) was added to the reaction solution, and the mixed solution was stirred for 30 minutes. After separating the organic layer and the aqueous layer, the organic layer was washed with water (300 mL×2 times). After concentrating the organic layer under reduced pressure to a volume of 1.5 to 2.5 v, n-heptane (30 to 50 mL) was added thereto and the mixture was stirred at room temperature for 1 hour, and n-heptane (200 mL) was added thereto and the mixture was stirred at room temperature for 16 hours. The resulting solid was collected by filtration and washed with n-heptane (70 mL), and thereby the title compound (25.2 g) was obtained as an off-white solid.

Example 2f

[0238] TEMPO oxidation was performed in flow mode using a continuous stirred tank reactor (CSTR) shown in FIG. **1**. Tert-butyl-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (Formula (A-5)) (276.6 g) obtained in the same manner as in the methods of (Examples 1a to 1d), TEMPO (82.588 g, 0.5 eq), and dichloromethane (5,535 mL, 20 v) were added into a vessel M**1**, and KBr (6.251 g), sodium hydrogen carbonate (352.943 g), and water (4,149 mL) were added into

a vessel M**2**, and 5.0 wt % NaClO (1.849 L) was added into a vessel M**3**. While flowing nitrogen gas from the respective nitrogen inlets L**1**, L**2**, L**3**, and L**4**, the reagents were flowed from M**1**, M**2**, and M**3** at each flow rate of 13.67 mL/min, 9.83 mL/min, and 4.27 mL/min using the respective pumps P**1**, P**2**, and P**3**, then were passed through the respective pre-cooling tubes T**1**, T**2**, and T**3** (temperature 0° C. to 5° C., tube length: 2 m, tube diameter: 1/16 SS), then were sequentially passed through the reactor R**1**, the reactor R**2**, and the reactor R**3** (where each of the reactors 1, 2, and 3 had a capacity of 25 mL, and the respective reactors were cooled to 0° C. to 5° C.), and thereby were poured into a recovery drum CD (where a reaction time in each of the reactors in flow mode was 0.9 minutes, and it required 410 minutes to complete the flow). A 3.7% Na.sub.2S**2**O**4** solution (2,597 g) was added to 6,845 g of the obtained reaction mixed solution, and the mixed solution was stirred for 30 minutes. After separating the organic layer and the aqueous layer, the organic layer was washed with water (3 L x 2 times). After concentrating the organic layer under reduced pressure to a volume of 2.5 v, n-heptane (205 mL) and one fragment of the already obtained compound represented by Formula A-6 were added thereto and the mixture was stirred at room temperature for 1 hour. Furthermore, n-heptane (2.1 L) was added thereto, and the resulting solid was collected by filtration, washed with n-heptane (800 mL), and dried under reduced pressure for 13 hours to obtain the title compound (190 g) as a brown solid.

[Data of Physical Properties of Compound Represented by Formula (A-6)]

[0239] (.sup.1H NMR, 400 MHz, manufacturer: Bruker, CDCl.sub.3, δ ppm)

[0240] 7.42 (d, 1H, J=7 Hz), 7.14 (t, 1H, J=7 Hz), 6.97 (d, 1H, J=7 Hz), 6.12 (s, 1H), 3.41 (s, 2H), 3.01 (t, 2H, J=6 Hz), 2.51 (dd, 2H, J=6 Hz, 7 Hz), 1.44 (s, 9H)

(Examples 3a to 3g) Synthesis of tert-butyl (R)-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (A-7)

##STR00057##

Example 3a

[0241] KRED (ketone reductase derived from Lactobalius sp., 2.0 g), D-glucose (0.2 g), glucose dehydrogenase (GDH) (0.02 g), nicotinamide adenine dinucleotide phosphate (NADP) (0.01 g), and a phosphate buffer solution (3.0 mL, prepared by adding 21.25 g of K.sub.2HPO.sub.4 and 10.62 g KH.sub.2PO.sub.4 to 1,000 mL of water) were mixed into a glass flask (capacity 8 mL) and stirred to prepare a mixed solution A. A mixed solution obtained by dissolving the compound (0.1 g) of Formula (A-6) obtained in the same manner as in the methods of (Examples 2a to 2f) in dimethyl sulfoxide (DMSO) (0.2 mL) was added into the previously prepared mixed solution A. The mixture was stirred at a reaction temperature of 23° C. (20° C. to 25° C.) for 43 hours (at 250 rpm in an orbital shaker). Some parts of the reaction solution were sampled and subjected to HPLC analysis, and it was confirmed that the title compound was obtained.

[0242] KRED used in Examples 3a to 3g is a ketone reductase derived from *Lactobacillus* sp. (EnzymeWorks, Inc., product number: EW-KRED-172).

Example 3b

[0243] KRED (ketone reductase derived from Lactobalius sp., 20 g), D-glucose (2 g), glucose dehydrogenase (GDH) (0.2 g), nicotinamide adenine dinucleotide phosphate (NADP) (0.1 g), and a buffer solution (prepared by adding 0.86 g of K.sub.2HPO.sub.4-3H.sub.2O and 0.3 g of KH.sub.2PO.sub.4 to 30 mL of water) were mixed into a reactor and stirred to prepare a mixed solution B. A mixed solution obtained by dissolving the compound (1 g) of Formula (A-6) obtained in the same manner as in the methods of (Examples 2a to 2f) in toluene (13 mL) was added into the previously prepared mixed solution B. The mixture was stirred at a reaction temperature of 23° C. (20° C. to 25° C.) for 15 hours. The reaction solution was filtered using a Celite, and the aqueous layer and the organic layer were separated, then the aqueous layer was extracted with toluene (30 mL), and the organic layer was combined with the previously obtained organic layer, and then washed with water (30 mL×2 times), then concentrated to obtain the title compound (0.5 g, optical purity 99.9% ee) as a brown oil.

Example 3c

[0244] An investigation of the amount of KRED and a pH were performed under reaction conditions shown in the table below. The compound represented by Formula (A-6) was obtained in the same manner as in the methods of (Examples 2a to 2f). A buffer solution was prepared from K.sub.2HPO.sub.4-3H.sub.2O and KH.sub.2PO.sub.4 in the same manner as in Example 3b.

TABLE-US-00010 TABLE 10 Conditions Enzyme IPC (times = Solvent Reaction step purity A-6 times its D- (times = times Temp. Time A7 No. (g) pH weight) glucose its volume) (° C.) (h) (%) 1 0.5 6.5-7.0 KRED 5 2.0 Toluene 13 times 20 to 25 112 93.8 times times Buffer solution GDH 0.2 30 times times NADP 0.1 times 2 0.5 6.5-7.0 KRED 10 2.0 Toluene 13 times 20 to 25 112 97.3 times times Buffer solution GDH 0.2 30 times times NADP 0.1 times 3 0.5 6.0-6.5 KRED 5 2.0 Toluene 13 times 20 to 25 40 83.1 times times Buffer solution GDH 0.2 30 times times NADP 0.1 times 4 0.5 6.5-7.0 KRED 5 2.0 Toluene 13 times 20 to 25 40 90.1 times times Buffer solution GDH 0.2 30 times times NADP 0.1 times 5 0.5 7.0-7.5 KRED 5 2.0 Toluene 13 times 20 to 25 40 84.5 times times Buffer solution GDH 0.2 30 times times NADP 0.1 times

(Example 3d) ,M

[0245] An investigation of the amount of the solvent was performed under reaction conditions shown in the table below. The compound represented by Formula (A-6) was obtained in the same manner as in the methods of (Examples 2a to 2f). A buffer solution was prepared from K.sub.2HPO.sub.4-3H.sub.2O and KH.sub.2PO.sub.4 in the same manner as in Example 3b.

TABLE-US-00011 TABLE 11 Conditions Enzyme IPC (times = Solvent Reaction step purity A-6 times its D- (times = times Temp. Time A7 No. (g) pH weight) glucose its volume) (° C.) (h) (%) 1 0.5 6.5-7.0 KRED 10 2.0 Toluene 5 times 20 to 25 18 95.6 times times Buffer solution GDH 0.2 30 times times NADP 0.1 times 2 0.5 6.5-7.0 KRED 10 2.0 Toluene 10 times 20 to 25 18 93.3 times times Buffer solution GDH 0.2 30 times times NADP 0.1 times

Example 3e

[0246] An investigation of an amount of the buffer solution, an amount of the raw material, and an amount of KRDE were performed under reaction conditions shown in the table below. The compound represented by Formula (A-6) was obtained in the same manner as in the methods of (Examples 2a to 2f). A buffer solution was prepared from K.sub.2HPO.sub.4.Math.3H.sub.2O and KH.sub.2PO.sub.4 in the same manner as in Example 3b.

TABLE-US-00012 TABLE 12 Conditions Enzyme IPC (times = Solvent Reaction step purity A-6 times its D- (times = times Temp. Time A7 No (g) pH weight) glucose its volume) (° C.) (h) (%) 1 5 6.5-7.0 KRED 10 2.0 Toluene 5 times 20 to 25 4 67.0 times times Buffer solution 23 95.5 GDH 0.2 30 times 87 95.3 times NADP 0.1 times 2 0.5 6.5-7.0 KRED 5 2.0 Toluene 5 times 20 to 25 16 84.7 times times Buffer solution 26 93.2 GDH 0.2 30 times 46 95.7 times 72 95.9 NADP 0.1 times 3 0.5 6.5-7.0 KRED 10 2.0 Toluene 5 times 20 to 25 18 89.0 times times Buffer solution 28 94.2 GDH 0.2 15 times 48 96.2 times 74 95.8 NADP 0.1 times

Example 3f

[0247] An enzymatic reaction was performed for 23 hours with a pH of a reaction solution 6.0 to 7.0 and at a reaction temperature of 23° C. (20° C. to 25° C.), and then for 16 hours at 50° C. to 60° C. using the compound (10 g) of Formula (A-6) obtained in the same manner as in the methods of (Examples 2a to 2f), toluene (50 mL), a buffer solution (300 mL, a composition of K.sub.2HPO.sub.4.Math.3H.sub.2O and KH.sub.2PO.sub.4 was the same as in the above-described examples), KRED (100 g), D-glucose (20 g), NADP (0.25 g), and GDH (0.5 g), then work up was performed according to the above-mentioned work up method, and thereby the title compound (11.75 g) was obtained as a dark red oil.

Example 3g

[0248] KRED (1,279 g), D-glucose (253 g), NADP (12.61 g), and GDH (25.26 g) were added into a buffer solution (3,780 mL) prepared by dissolving K.sub.2HPO.sub.4.Math.3H.sub.2O (108.4 g) and KH.sub.2PO.sub.4 (37.82 g) in water (3,780 mL) to prepare a mixed solution (MS-6-1), and

then the mixed solution was stirred for 1 hour. A mixed solution obtained by dissolving the compound (126.05 g) of Formula (A-6) obtained in the same manner as in the methods of (Examples 2a to 2f) in toluene (630 mL) was added into the previously prepared mixed solution (MS-6-1). The reaction solution was stirred at a reaction temperature of 23° C. (20° C. to 25° C.) for 26 hours while maintaining a pH of the reaction solution at pH=6.0 to 7.0. Tert-amyl alcohol (500 mL) and isoamyl alcohol (130 mL) were added into the reaction solution, and the mixed solution was stirred at a reaction temperature of 23° C. (20° C. to 25° C.) for 16 hours. Ethyl acetate (1,300 mL) and a Celite (126 g) were added thereto, a temperature was raised to 60° C., and the mixture was stirred at the same temperature for 1 hour. After cooling to 20° C., filtration was performed and the aqueous layer and the organic layer were separated, and the aqueous layer was extracted with ethyl acetate (1,300 mL), then the organic layer was combined with the previously obtained organic layer, and then washed with water (1,300 mL) to obtain an organic layer (OP-6-1). Furthermore, ethyl acetate (1,300 mL) was added to the filtered Celite, and the mixture was stirred at 20° C. to 30° C. for 10 hours and filtered to obtain an organic layer (OP-6-2), and once again ethyl acetate (1,300 mL) was added to the filtered Celite, and the mixture was stirred at 20° C. to 30° C. for 2 hours and filtered to obtain an organic layer (OP-6-3). The organic layer (OP-6-1), the organic layer (OP-6-2), and the organic layer (OP-6-3) were combined to form an organic layer (OP-6A). Furthermore, the reaction was performed in the same manner as in the method described above using the compound (113 g) of Formula (A-6) obtained in the same manner as in the methods of (Examples 2a to 2f), and thereby an organic layer (OP-6B) was obtained. The organic layer (OP-6A) and the organic layer (OP-6B) were combined and then concentrated, and thereby the title compound (331 g) was obtained as a reddish brown oil.

[Data of Physical Properties of Compound Represented by Formula (A-7)]

[0249] (.sup.1H NMR, 400 MHz, manufacturer: Bruker, CDCl.sub.3, δ ppm)

[0250] 7.51 (d, 1H, J=7 Hz), 7.05 (t, 1H, J=7 Hz), 6.80 (d, 1H, J=7 Hz), 6.19 (brs, 1H), 4.10-4.05 (1H, m), 2.92-2.81 (2H, m), 2.80-2.69 (1H, m), 2.43 (dd, 1H, J=7 Hz, 16 Hz), 2.03-1.88 (1H, m), 1.78-1.63 (1H, m), 1.45 (9H, s)

[0251] An absolute configuration of the compound represented by Formula (A-7) was determined by converting the compound represented by Formula (A-7) to the compound represented by Formula (B), thereafter, comparing an analytical data thereof to that of a compound represented by Formula (B) synthesized separately by a method disclosed in WO 2003/095420, and the like, and confirming whether those analytical data matched. Furthermore, whether hydroxyl groups in the compound represented by Formula (B) had the (R) configuration was determined by converting the compound represented by Formula (B) to a hydrobromide thereof, and analyzing the hydrobromide with an X-ray crystal structure (refer to (Example 5) and FIG. **2**).

(Example 4a) Synthesis of hydrochloride of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (Formula B-HCl)

##STR00058##

[0252] n-PrOH (2 g) was added into a reactor and stirred at −5° C. to 5° C. Acetyl chloride (0.76 g) was added dropwise at the same temperature over 10 minutes. After raising a reaction temperature to 50° C. to 55° C., a solution of the compound (0.5 g) of Formula (A-7) obtained in the same manner as in the methods of (Example 3a to g) in n-PrOH (6 g) was added to the mixture over 45 minutes. After stirring at a reaction temperature of 50° C. to 55° C. for 45 minutes, the mixture was allowed to cool so that the reaction temperature reached between 20° C. and 30° C., and the mixture was stirred at 20° C. to 30° C. for 16 hours. The obtained solid was filtered, washed with n-PrOH (5 mL×2 times), and dried at 40° C. to 50° C. for 6.5 hours to obtain the title compound (0.23 g).

(Example 4b) Synthesis of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (Formula B)

##STR00059##

[0253] n-PrOH (1.81 g) was added into a reactor and stirred at −5° C. to 5° C. Acetyl chloride (2.35

g) was added dropwise at the same temperature over 10 minutes. After raising a reaction temperature to 33° C. to 37° C., a solution of the compound (4.25 g) of Formula (A-7) obtained in the same manner as in the methods of (Example 3a to g) in n-PrOH (12.75 g) was added to the mixture over 45 minutes. After stirring at a reaction temperature of 33° C. to 37° C. for 49.5 hours, the mixture was stirred at a reaction temperature of 20° C. to 25° C. for 19 hours. The generated solid was filtered, washed with i-PrOAc (10 mL×2 times), and dried at 30° C. to 40° C. for 4 hours to obtain a hydrochloride (2.04 g). After the separately synthesized hydrochloride (0.07 g) were combined to make 2.11 g, the combined product was suspended in ethyl acetate (12 mL), and a pH of the aqueous layer was adjusted to 7 to 8 using an aqueous solution of sodium hydrogen carbonate. After the aqueous layer and the organic layer were separated, the aqueous layer was extracted with ethyl acetate (12 mL×2 times), and the organic layers were combined, washed with water (10 mL×2 times), then concentrated under reduced pressure to obtain the title compound (1.34 g).

(Example 4c) Synthesis of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (Formula B)

[0254] n-PrOH (138 g) was added into a reactor and stirred at −5° C. to 5° C. Acetyl chloride (180.1 g) was added dropwise at the same temperature over 1 hour. After raising a reaction temperature to 33° C. to 37° C., a solution of a crude compound (331 g) of Formula (A-7) obtained in the same manner as in the methods of (Example 3a to g) in n-PrOH (750 mL) was added to the mixture over 45 minutes. After stirring at a reaction temperature of 33° C. to 37° C. for 15 hours, the mixture was stirred at a reaction temperature of 50° C. to 55° C. for 2 hours and 10 minutes. After a reaction temperature was set to 33° C. to 37° C., a mixed solution obtained by adding HCl (gass) (26 g) to i-PrOAc (192 g) was added to the mixture at 33° C. to 37° C. over 30 minutes. The reaction temperature was raised to 50° C. to 55° C., and the mixture was stirred for 1.5 hours. The produced solid was filtered, washed with i-PrOAc, and dried under reduced pressure at 20° C. to 30° C. for 36 hours to obtain a hydrochloride (158 g). The hydrochloride (158 g) was suspended in ethyl acetate (1,000 mL), and an aqueous solution of sodium hydrogen carbonate (76 g of sodium hydrogen carbonate, 1,000 mL of water) was added thereinto over 30 minutes. After the aqueous layer and the organic layer were separated, the aqueous layer was extracted with ethyl acetate (1,000 mL×2 times), and the organic layers were combined, washed with water (1,000 mL), and concentrated under reduced pressure to obtain the title compound (136 g).

[Data of Physical Properties of Compound Represented by Formula (B)]

[0255] (.sup.1H-NMR, 400 MHz, manufacturer: Bruker, CDCl.sub.3, δ ppm) 6.91 (1H, t, J=7 Hz), 6.52-6.46 (2H, m), 4.19-4.04 (2H, m), 3.51 (1H, brs), 2.93-2.65 (3H, m), 2.31 (1H, dd, J=7 Hz, 16 Hz), 2.02-1.89 (1H, m), 1.85-1.65 (1H, m)

(Example 5) Synthesis of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol hydrobromide (Formula (B-HBr))

##STR00060##

[0256] A crude compound (99.9 g) of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol obtained by the same operation as in (Example 4b) or (Example 4c) was dissolved in ethyl acetate (1 L), and an aqueous solution of 48% hydrobromic acid (80 mL) was added to the mixture under ice-water cooling. The precipitated solid was collected by filtration and washed successively with isopropanol (300 to 400 mL) and ethyl acetate (500 mL). The obtained crude hydrobromide (123.9 g, 98.3% ee) was dissolved in hot water (250 mL), and activated carbon (20 g) was added thereto. The activated carbon was filtered using a Celite when it was hot, and washed with water. The filtrate was concentrated under reduced pressure, and the obtained residue was recrystallized with water. The obtained crystals were collected by filtration, and washed with isopropanol and ethyl acetate to obtain the title compound (34.2 g, 98.4% ee) was obtained. The filtrate was collected, concentrated under reduced pressure, and recrystallized twice with water to obtain the title compound (29.1 g, 98.9% ee).

[0257] An optical purity of the hydrobromide of the compound represented by Formula (B) was

measured using a HPLC LC-10 system of Shimadzu Corporation under the following conditions.
TABLE-US-00013 TABLE 13 Column CHIRALCEL OJ-H ID 4.6 × 250 mm (Daicel) Elution n-Hexane/Ethanol/Diethylamine = solvent 50/50/0.1 (v/v/v) Flow rate 0.5 mL/min Column temperature 20° C. Measurement 254 nm wavelength Elution time R form - 11.2 minutes, S form - 12.5 minutes
[0258] Furthermore, an X-ray crystal structure of a single crystal of the obtained hydrobromide of the compound represented by Formula (B) ((R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol) was analyzed using AFC-7 of Rigaku, and the following results were obtained (refer to FIG. **2**).
TABLE-US-00014 TABLE 14 Crystal system Monoclinic Space group P21 (#4) Unit cell dimensions a = 7.7320 (19) Å, α = 90.02 (3)°, b = 8.681 (3) Å, β = 103.47°, c = 8.017 (2) Å, γ = 90.00 (2)° Volume 523.3 (3) Å3 Refinement method Full-matrix least-squares Data/restraints/parameters 1549/1/121 Goodness-of-fit on F2 1.430 Final R indices R1 = 0.0590, [I > 2sigma(I)] wR2 = 0.1710 R indices R1 = 0.1033, (all data) wR2 = 0.2584 Absolute structure −0.06 (5) parameter Largest diff, 0.296 and peak and hole −0.384 e.Å−3
(Example 6) Synthesis of (E)-2-(7-trifluoromethylchroman-4-ylidene)-N-[(7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl]acetamide (Formula (I))
##STR00061##
[0259] Triethylamine (0.27 mL, 1.0 eq) and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (0.80 g, 1.5 eq) were added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol hydrobromide (Formula (B-HBr)) (0.47 g) obtained in (Example 5) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (Formula (CA-1)) (0.50 g, 1.0 eq) obtained by a production method disclosed in WO 2007/010383 in methanol (5.00 mL: about 10 times its volume with respect to 1 g of the compound represented by Formula (B-HBr)), and the mixture was stirred at room temperature for 3 hours. After the reaction solution was ice-cooled, the precipitated crystals were collected by filtration and washed with cold methanol. The obtained solid was dissolved in ethanol (6 mL) by heating, and then water (6 mL) was added during heating. After cooling the mixture, the precipitated solid was filtered, washed successively with 50% water-ethanol and water, and then dried under reduced pressure to obtain the title compound (0.56 g) as a white solid.
[Data of Physical Properties of Compound Represented by Formula (I)]
[0260] (.sup.1H-NMR data (CDCl.sub.3) (δ: ppm)):
[0261] 7.80-7.58 (m, 1H), 7.24-6.92 (m, 5H), 6.45 (s, 1H), 4.29 (t, 2H, J=6 Hz), 4.28-4.15 (m, 1H), 3.51 (t, 2H, J=5 Hz), 3.10-2.78 (m, 3H), 2.69-2.53 (m, 1H), 2.14-2.00 (m, 1H), 1.90-1.67 (m, 2H)
[0262] (LC-MS):
[0263] RT=4.73 (minutes), [M+H].sup.+=404
[0264] Optical purity: 97.9% ee
[0265] An optical purity of the compound represented by Formula (I) was measured using a HPLC LC-VP system of Shimadzu Corporation under the following conditions.
TABLE-US-00015 TABLE 15 Column CHIRALCEL AD-H ID 4.6 × 250 mm (Daicel) Elution solvent Ethanol Flow rate 0.5 mL/min Column temperature 40° C. Measurement 254 nm wavelength Elution time Compound represented by Formula (I) - 10.5 minutes, Enantiomer of compound represented by Formula (I) - 18.6 minutes
[0266] The crystal structure of the compound represented by Formula (I) was analyzed at a SPring-8 beamline BL32B2 using an R-AXIS V detector of Rigaku (refer to FIG. **3**).
TABLE-US-00016 TABLE 16 Crystal system Monoclinic Space group P21 (#4) Unit cell dimensions a = 16.344 Å, α = 90°, b = 7.272 Å, β = 113.80°, c = 19.088 Å, γ = 90° Volume 2075.6 Å3 Z 4 Density (calculated) 1.291 Mg/m.sup.3 Refinement method Full-matrix least-squares Data/restraints/parameters 5861/1/581 Goodness-of-fit on F2 1.123 Final R indices R1 = 0.0590, [I > 2sigma(I)] wR2 = 0.1710 R indices R1 = 0.0653, (all data) wR2 = 0.1795 Largest diff, 0.408 and peak and hole −0.323 e.Å−3

(Example 7) Synthesis of (E)-2-(7-trifluoromethylchroman-4-ylidene)-N-[(7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl]acetamide: (Examination (1) of conditions for condensation reaction)
##STR00062##
[0267] <Examination 1> Triethylamine (120 μL, 1.05 eq) and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (339 mg, 1.5 eq) were added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol hydrobromide (200 mg) obtained in (Example 5) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (212 mg, 1.0 eq) obtained by a production method disclosed in WO 2007/010383 in methanol (3.15 mL: 15.75 times its volume with respect to 1 g of the compound represented by Formula (B-HBr)), and the mixture was stirred at room temperature for 3 hours. Water was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (291 mg) as a white solid.
[0268] <Examination 2> Triethylamine (240 μL, 2.1 eq) and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (339 mg, 1.5 eq) were added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol hydrobromide (200 mg) obtained in (Example 5) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (212 mg, 1.0 eq) obtained by a production method disclosed in WO 2007/010383 in methanol (3.15 mL: 15.75 times its volume with respect to 1 g of the compound represented by Formula (B-HBr)), and the mixture was stirred at room temperature for 3 hours. Water was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (273 mg) as a white solid.
[0269] <Examination 3> Triethylamine (120 μL, 1.05 eq) and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (339 mg, 1.5 eq) were added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol hydrobromide (200 mg) obtained in (Example 5) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (212 mg, 1.0 eq) obtained by a production method disclosed in WO 2007/010383 in methanol (1.60 mL: 8 times its volume with respect to 1 g of the compound represented by Formula (B-HBr)), and the mixture was stirred at room temperature for 3 hours. Water was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (298 mg) as a white solid.
[0270] <Examination 4> Triethylamine (120 μL, 1.05 eq) and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (339 mg, 1.5 eq) were added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol hydrobromide (200 mg) obtained in (Example 5) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (212 mg, 1.0 eq) obtained by a production method disclosed in WO 2007/010383 in methanol (3.15 mL: 15.75 times its volume with respect to 1 g of the compound represented by Formula (B-HBr)), and the mixture was stirred under heating reflux for 3 hours. After cooling the mixture, water was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (291 mg) as a white solid.
[0271] In <Examination 1> to <Examination 4> of (Example 7) described above, generating of the endo product of the compound represented by Formula (I) ((R)-N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-2-(7-(trifluoromethyl)-2H-chromen-4-yl)acetamide) was suppressed.
[0272] A chemical purity of the compound represented by Formula (I) was measured using a HPLC LC-VP system of Shimadzu Corporation under the following conditions.
TABLE-US-00017 TABLE 17 Column Develosil ODS-HG-5 ID 4.6 × 150 mm (NOMURA CHEMICAL CO., LTD.) Elution solvent Acetonitrile/water = 50/50 (v/v) Flow rate 1.0 mL/min Column temperature 40° C. Measurement 273 nm wavelength Elution time Endo product of compound represented by Formula (I) - 5.9 minutes, Compound represented by Formula (I) - 9.1 minutes
(Example 8) Synthesis of (E)-2-(7-trifluoromethylchroman-4-ylidene)-N-[(7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl]acetamide: (Examination (2) of conditions for condensation reaction)
##STR00063##
[0273] <Examination 1>4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium P.sub.GP-

1.sub.02,C.sub.3,M chloride (DMT-MM) (257 mg, 1.5 eq) was added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (101 mg) obtained in the same operation as that in (Example 4b) or (Example 4c) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (200 mg, 1.25 eq) obtained by a production method disclosed in WO 2007/010383 in isopropanol (3.0 mL: about 30 times its volume with respect to 1 g of the compound represented by Formula (B)), and the mixture was stirred at room temperature for 6 hours. Water (3 mL) was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (209 mg) as a white solid.

[0274] <Examination 2>4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (257 mg, 1.5 eq) was added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (126 mg) obtained in the same operation as that in (Example 4b) or (Example 4c) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (200 mg, 1.0 eq) obtained by a production method disclosed in WO 2007/010383 in isopropanol (3.00 mL: about 24 times its volume with respect to 1 g of the Formula (B)), and the mixture was stirred at room temperature for 6 hours. Water (3 mL) was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (238 mg) as a white solid.

[0275] <Examination 3>4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (257 mg, 1.5 eq) was added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (152 mg) obtained in the same operation as that in (Example 4b) or (Example 4c) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (200 mg, 0.83 eq) obtained by a production method disclosed in WO 2007/010383 in isopropanol (3.00 mL: about 20 times its volume with respect to 1 g of the compound represented by Formula (B)), and the mixture was stirred at room temperature for 6 hours. Water (3 mL) was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (243 mg) as a white solid.

[0276] <Examination 4>4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (257 mg, 1.5 eq) was added to a suspension of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (177 mg) obtained in the same operation as that in (Example 4b) or (Example 4c) and (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (200 mg, 0.71 eq) obtained by a production method disclosed in WO 2007/010383 in isopropanol (3.00 mL: about 20 times its volume with respect to 1 g of the compound represented by Formula (B)), and the mixture was stirred at room temperature for 6 hours. Water (3 mL) was added thereto, and the precipitated solid was filtered, washed with water, and dried to obtain the title compound (238 mg) as a white solid.

(Example 9a) Synthesis of (E)-2-(7-trifluoromethylchroman-4-ylidene)-N-[(7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl]acetamide

[0277] After a condensation reaction (reaction conditions: 20° C. to 25° C., stirring for 22 hours) was performed using (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (1.04 g, purity 99.35%) obtained in the same operation as that in (Example 4b) or (Example 4c), (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (1.05 eq) obtained by a production method disclosed in WO 2007/010383, isopropanol (25 times its volume with respect to the compound represented by Formula (B)), and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (1.3 eq), a work up was performed according to (Example 8), and thereby the title compound (1.87 g) was obtained as a solid.

(Example 9b) Synthesis of (E)-2-(7-trifluoromethylchroman-4-ylidene)-N-[(7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl]acetamide (scale-up)

[0278] After a condensation reaction (reaction conditions: 20° C. to 25° C., stirring for 22 hours) was performed using (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (110 g) obtained in the same operation as that in (Example 4b) or (Example 4c), (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (173.9 g, 1.05 eq) obtained by a production method disclosed in WO

2007/010383, isopropanol (2,600 mL: 25 times its volume with respect to the compound represented by Formula (B)), and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (243.7 g, 1.3 eq), a work up was performed according to (Example 8), and thereby the title compound (183.3 g) was obtained as a grayish-white solid.

[0279] An optical purity of the compound represented by Formula (I) was measured using a HPLC LC-VP system of Shimadzu Corporation under the following conditions.

TABLE-US-00018 TABLE 18 Column CHIRALCEL AD-H ID 4.6 × 250 mm (Daicel) Elution solvent Ethanol Flow rate 0.5 mL/min Column temperature 40° C. Measurement 254 nm wavelength Elution time Compound represented by Formula (I) - 10.5 minutes, Enantiomer of compound represented by Formula (I) - 18.6 minutes

[0280] Bruker AV 400 was used for measurement of nuclear magnetic resonance (NMR) spectra of the compounds represented by Formula (A8-BR) and Formula (B). The high-performance liquid chromatography (HPLC) of compounds represented by Formula (A8-BR) and Formula (B) were measured by the following method.

TABLE-US-00019 TABLE 19 Measurement conditions for compound represented by Formula (A8-BR) Measuring Thermo U-3000 with UV instrument detector or equivalent Column Waters Xbridge C18 (4.6 mm × 150 mm, 3.5 μm) Measurement 220 nm wavelength Column temperature 35° C. Flow rate 1.0 mL/min Injection capacity 5 μL Sample 0.5 mg/mL concentration Performance time 21 min Data collection time 21 min Dilution agent ACN:H.sub.2O = 50:50 (v/v) Mobile phase A 10 mM NH.sub.4Ac in H.sub.20 Mobile phase B ACN Time Mobile phase Mobile phase (min) A (%) B (%) Gradient Initial time 90 10 program 13.00 15 85 15.00 15 85 16.00 90 10 21.00 90 10 Rebalancing time: 21 minutes

TABLE-US-00020 TABLE 20 Retention time (RT) RT Relative retention Compound (min) time (RRT) Formula (SM8-BR) 10.6 1.1 Formula (A8-BR) 9.7 1.0

TABLE-US-00021 TABLE 21 Measurement conditions for compound represented by Formula (B) Measuring Thermo U-3000 with UV instrument detector or equivalent Column ACE 3 C18 (150 mm × 4.6 mm, 3 μm) Measurement 213 nm wavelength Column temperature 35° C. Flow rate 1.0 mL/min Injection capacity 5 μL Sample 0.12 mg/mL concentration Performance time 16 min Data collection time 16 min Dilution agent MeOH Mobile phase A 5 mM NH.sub.4Ac in H2O Mobile phase B ACN Time Mobile phase Mobile phase (min) A (%) B (%) Gradient Initial time 95 5 program 4.00 70 30 10.0 10 90 11.0 10 90 12.0 95 5 16.0 stop stop Rebalancing time: 16 minutes

TABLE-US-00022 TABLE 22 Retention time (RT) RT Relative retention Compound (min) time (RRT) Formula (B) 6.9 1.0 Formula (A8-BR) 9.7 1.4

TABLE-US-00023 TABLE 23 Chiral analysis method for compound represented by Formula (A8-BR) Measuring Shimadzu LC-20A HPLC with PDA instrument detector or equivalent Column Daicel Chiralpak IB (250 mm × 4.6 mm, 5 μm) Measurement 273 nm wavelength Column temperature 35° C. Flow rate 1.0 mL/min Injection capacity 5 μL Sample 0.6 mg/mL concentration Data collection time 15 min Performance time 15 min Dilution agent EtOH Mobile phase Hexanes: 0.1% ethanolamine in EtOH = 95:5 (v/v) Time Mobile phase (min) (%) Isocratic 0.0 100 program 15.0 stop

TABLE-US-00024 TABLE 24 Retention time (RT) RT Relative retention Compound (min) time (RRT) Formula (A8-BR) 7.9 1.00 Enantiomer of Formula 7.0 0.89 (A8-BR)

TABLE-US-00025 TABLE 25 Chiral analysis method for compound represented by Formula (B) Measuring Agilent 1260 HPLC with UV instrument detector or equivalent Column Daicel Chiralcel OJ-H (250 × 4.6 mm, 5.0 μm) Measurement 237 nm wavelength Column temperature 25° C. Flow rate 0.5 mL/min Injection capacity 5 μL Sample 0.6 mg/mL concentration Data collection time 11.0 min Performance time 25 min Dilution agent EtOH Mobile n-Hexane:Ethanol:DEA phase (50:50:0.1, v/v/v) Time Mobile phase (min) (%) Isocratic 0.00 100% program 25.00 stop

TABLE-US-00026 TABLE 26 Retention time (RT) RT Relative retention Compound (min) time (RRT) Formula (B) 11.0 1.00 Enantiomer of 12.1 1.10 Formula (B)

(Example 10A) to (Example 10D) Synthesis of (R)-8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol (A8-BR)

##STR00064##

Example 10A

[0281] KRED (ketone reductase derived from *Escherichia coli* sp., 5 mg), D-glucose (200 mg), glucose dehydrogenase (GDH) (2 mg), nicotinamide adenine dinucleotide phosphate (NADP) (1 mg), and a phosphate buffer solution (3 mL, prepared by adding 10.62 g of KH.sub.2PO.sub.4 and 21.25 g of K.sub.2HPO.sub.4 to 1,000 mL of water) were mixed into a flask equipped with an orbital shaker (manufactured by Shanghai Nanrong Laboratory Equipment Co., Ltd., model number: NRY-200) and stirred to prepare a mixed solution. Next, a mixed solution obtained by dissolving 8-bromo-3,4-dihydronaphthalen-2(1H)-one (Formula (SM8-BR)) (100 mg) in dimethyl sulfoxide (DMSO) (0.3 mL) was added into the previously prepared mixed solution, and the mixture was stirred at a reaction temperature of 30° C. for 20 hours (where a rotation speed of an orbital shaker was 250 rpm). Some parts of the reaction solution were sampled and subjected to HPLC analysis, and it was confirmed that the title compound was obtained with an IPC yield (IPC=in process control) of 97.8% and an optical purity of 99.7%.

Example 10B

[0282] KRED (ketone reductase derived from *Escherichia coli* sp., 0.25 g), D-glucose (10 g), glucose dehydrogenase (GDH) (0.1 g), nicotinamide adenine dinucleotide phosphate (NADP) (0.05 g), and a buffer solution (1.55 g of KH.sub.2PO.sub.4 and 4.06 g of K.sub.2HPO.sub.4-3H.sub.2O were added to 145 mL of water) were mixed into a reactor to prepare a mixed solution, and it was stirred at 20° C. to 25° C. Next, a mixed solution obtained by dissolving 8-bromo-3,4-dihydronaphthalen-2(1H)-one (Formula (SM8-BR)) (5 g) in dimethyl sulfoxide (DMSO) (15 mL) was added dropwise into the previously prepared mixed solution. After stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Next, after stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Furthermore, after stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Thereafter, the reaction solution was stirred at a reaction temperature of 20° C. to 25° C. for 16 hours (some parts of the reaction solution were sampled and subjected to HPLC analysis, and it was confirmed that an IPC yield of the title compound was 99.6%). Methyl tert-butyl ether (MTBE) (50 mL) was added into the reaction solution, and diatomite (diatomaceous earth) (5 g) containing water (5 g) was further added thereinto, then the mixed solution was stirred at a temperature of 50° C. to 60° C. for 30 minutes. The temperature of the mixed solution was cooled to 20° C. to 25° C., and the mixed solution was further stirred at the same temperature for 1 hour. The mixed solution described above was filtered, and the filtered material (wet cake) was washed with MTBE (5 mL) to obtain a filtrate A. The wet cake described above was put in a reactor, and MTBE (40 mL) was added thereinto, then the mixture was stirred at 20° C. to 25° C. for 2 hours. The suspension containing the wet cake was filtered, and the wet cake was washed with MTBE (5 mL) to obtain a filtrate B. After mixing the filtrate A and the filtrate B and stirring the mixture at 20° C. to 30° C. for 5 minutes, the aqueous layer and the organic layer were separated, and the aqueous layer was extracted with MTBE (45 mL), then the organic layer was combined with the previously obtained organic layer, washed with water (30 mL), and concentrated to obtain a crude title compound (4.61 g). The obtained crude title compound was subjected to silica gel column chromatography (n-heptane:ethyl acetate=1:1) to obtain the title compound (4.15 g, optical purity 99.9%).

Example 10C

[0283] KRED (ketone reductase derived from *Escherichia coli* sp., 0.83 g), D-glucose (33.28 g),

glucose dehydrogenase (GDH) (0.33 g), nicotinamide adenine dinucleotide phosphate (NADP) (0.17 g), and a buffer solution (5.31 g of KH.sub.2PO.sub.4 and 13.89 g of K.sub.2HPO.sub.4-3H.sub.2O were added to 499 mL of water) were mixed into a reactor to prepare a mixed solution, and it was stirred at 20° C. to 25° C. Next, a mixed solution obtained by dissolving 8-bromo-3,4-dihydronaphthalen-2(1H)-one (Formula (SM8-BR)) (17.3 g) in dimethyl sulfoxide (DMSO) (50 mL) was added dropwise into the previously prepared mixed solution. After stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Next, after stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Furthermore, after stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Thereafter, the mixture was stirred at a reaction temperature of 20° C. to 25° C. for 16 hours. Some parts of the reaction solution were sampled and subjected to HPLC analysis, and it was confirmed that an IPC yield of the title compound was 97.4%. The same work up as in (Example 1B) was performed to obtain the title compound (17.12 g, optical purity 99.9%).

Example 10D

[0284] KRED (ketone reductase derived from *Escherichia coli* sp., 5.55 g), D-glucose (220 g), glucose dehydrogenase (GDH) (2.20 g), nicotinamide adenine dinucleotide phosphate (NADP) (1.12 g), and a buffer solution (35.12 g of KH.sub.2PO.sub.4 and 91.80 g of K.sub.2HPO.sub.4-3H.sub.2O were added to 3,300 mL of water) were mixed into a reactor to prepare a mixed solution, and it was stirred at 20° C. to 25° C. Next, a mixed solution obtained by dissolving 8-bromo-3,4-dihydronaphthalen-2(1H)-one (Formula (SM8-BR)) (110.31 g) in dimethyl sulfoxide (DMSO) (330 mL) was added dropwise into the previously prepared mixed solution. After stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Next, after stirring at a reaction temperature of 20° C. to 25° C. for 1 hour, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Furthermore, after stirring at a reaction temperature of 20° C. to 25° C. for 2 hours, a pH of the reaction solution was adjusted to be within a range of pH=6.5 to 7.0 using an aqueous solution of 2M sodium carbonate. Thereafter, the mixture was stirred at a reaction temperature of 20° C. to 25° C. for 16 hours. Some parts of the reaction solution were sampled and subjected to HPLC analysis, and it was confirmed that an IPC yield of the title compound was 97.4%.

[0285] MTBE (1,100 mL) was added into the reaction solution, and diatomite (diatomaceous earth) (110 g) containing water (110 g) was further added thereinto, and the mixed solution was stirred at a temperature of 50° C. to 60° C. for 30 minutes. The temperature of the mixed solution was cooled to 20° C. to 25° C., and the mixed solution was further stirred at the same temperature for 2 hours. The mixed solution described above was filtered, and the filtered material (wet cake) was washed with MTBE (110 mL) to obtain a filtrate C. The wet cake described above was put in a reactor, and MTBE (900 mL) was added thereinto, then the mixture was stirred at 20° C. to 25° C. for 12 hours. The suspension containing the wet cake was filtered, and the wet cake was washed with MTBE (110 mL) to obtain a filtrate D. The filtrate C and the filtrate D were mixed, and the aqueous layer and the organic layer were separated and the aqueous layer was extracted with MTBE (1,000 mL), then the organic layer was combined with the previously obtained organic layer, washed with water (675 mL), and concentrated to obtain a crude title compound (108.03 g, optical purity 99.8%).

[Data of Physical Properties of Formula (A8)]

[0286] (.sup.1H NMR, 400 MHz, manufacturer: Bruker, DMSO-d.sub.6, δ ppm)

[0287] 7.40 (d, 1H, J=8 Hz), 7.10 (d, 1H, J=8 Hz), 7.04 (t, 1H, J=8 Hz), 4.89 (d, 1H, J=4 Hz), 3.99-3.95 (m, 1H), 2.92-2.86 (m, 2H), 2.70-2.60 (m, 1H), 1.83-1.75 (m, 1H), 1.65-1.55 (m, 1H))

[0288] The KRED (ketone reductase derived from *Escherichia coli* sp.) used in (Example 10A) to

(Example 10D) is an enzyme manufactured by EnzymeWorks, Inc. (product number: HQ-K-105).
[0289] An absolute configuration of the compound represented by Formula (A8-BR) obtained in (Example 10A) to (Example 10D) was determined by converting the Formula (A8-BR) to the Formula (B), and thereafter, confirming whether an analytical data thereof matched an analytical data of a compound represented by Formula (B) synthesized separately by a method disclosed in WO 2003/095420, and the like.
(Reference Example 1) Synthesis of 8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol (Formula (A8-BR-Rac))
##STR00065##
[0290] 8-Bromo-3,4-dihydronaphthalen-2(1H)-one (Formula (SM8-BR)) (20.0 g) and methanol (200 mL) were added into a reactor, and NaBH.sub.4 (8.28 g) was added at an internal temperature of 0° C. to 5° C., and the mixture was stirred at the same temperature for 1 hour (some parts of the reaction solution were sampled and subjected to HPLC analysis, and it was confirmed that an IPC yield was 98.5%). An aqueous solution of 10% sodium hydrogen carbonate (1.5 L) was added dropwise when a temperature of the reaction solution was 5° C. or lower, and the mixed solution was stirred for 0.2 hours at a temperature of the mixed solution of 0° C. to 5° C. Ethyl acetate (1.5 L) was added, and the aqueous layer and the organic layer were separated then the aqueous layer was extracted with ethyl acetate (1.5 L), and the organic layer was combined with the previously obtained organic layer, washed with an aqueous solution of 25 wt % sodium chloride (1.5 L) and concentrated to obtain a crude title compound (21.53 g). The obtained crude title compound was subjected to silica gel column chromatography (n-heptane:ethyl acetate=1:1) to obtain the title compound (21.29 g). It was confirmed that the obtained compound represented by Formula (A8-BR-Rac) matched physical properties data known from a literature.
(Example 11A) to (Example 11G) Synthesis of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (Formula (B))
##STR00066##
Example 11A
[0291] (R)-8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol (Formula (A8-BR)) (100 mg) obtained by an enzymatic reduction in the same manner as in the methods of Example I0A to Example 10D, Cu.sub.2O (40 mg), N-methyl-pyrrolidone (NMP) (2 mL), and ammonia water (3 mL) were mixed in a sealed-tube reactor, and a sealed-tube reaction was performed at a temperature of 105° C. to 115° C. for 20 hours. After diluting the mixture with water, the mixture was extracted with ethyl acetate, and the organic layer was washed with an aqueous solution of 25 wt % sodium chloride, dried with Na.sub.2SO.sub.4, filtered, and concentrated to obtain a crude title compound (106 mg). Thin layer chromatography (n-heptane:ethyl acetate=1:1) was performed for separation, and thereby the title compound (10 mg) was obtained (optical purity 96.8%).
Example 11B
[0292] (R)-8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol (Formula (A8-BR)) (2.2 g) obtained by an enzymatic reduction in the same manner as in the methods of Example I0A to Example 10D, Cu.sub.2O (700 mg), NMP (3.5 mL, 1.6 v), and ammonia water (5.5 mL) were mixed in a sealed-tube reactor, and a sealed-tube reaction was performed at a temperature of 105° C. to 115° C. for 37 hours (it was confirmed that an IPC yield was 83.75% after 16 hours, 88.91% after 21 hours, and 93.12% after 37 hours). After diluting the mixture with water (17 mL) and ethyl acetate (11 mL), the mixture was filtered, and the filtered material was washed with ethyl acetate (4 mL, 3 times), then the aqueous layer and the organic layer were separated. Then, the aqueous layer was extracted with ethyl acetate (11 mL, 5 times), and the organic layer was combined with the previously obtained organic layer, washed with water (20 mL, 2 times), an aqueous solution of 10% Na.sub.2SO.sub.4, and concentrated to obtain a crude title compound (1.25 g, 61.27%, optical purity 95.6%).
Example 11C

[0293] The sealed-tube reaction was performed under conditions shown in the table below, and the reaction solvent was verified.

TABLE-US-00027 TABLE 27 Reaction IPC (%) Reagent (eq.) Condition @6.91 min Ex. No. A8-BR Cu.sub.2O NMP Temp./Time B 11C-1 1.90 g 0.60 g 4.8 mL 1 mL 105-115° C./13 h 63.97 (1.0 eq.) (0.50 eq.) (2.5 v) (0.5 v) 105-115° C./37 h 82.32 11C-2 2.07 g 0.66 g 5.2 mL 2 mL 105-115° C./13 h 66.46 (1.0 eq.) (0.51 eq.) (2.5 v) (1 v) 105-115° C./37 h 93.75 11C-3 1.90 g 0.60 g 4.8 mL 2.9 mL 105-115° C./13 h 70.34 (1.0 eq.) (0.50 eq.) (2.5 v) (1.5 v) 105-115° C./37 h 93.10

[0294] In Example 11C-2, 0.74 g (yield 50%) of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol was obtained, and in Example 11C-3, 0.5 g (36.6%) of (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol was obtained.

Example 11D

[0295] The sealed-tube reaction was performed under conditions shown in the table below, and an amount of the ammonia water was verified.

TABLE-US-00028 TABLE 28 Reaction IPC (%) Reagent (eq.) Condition @6.83 min Ex. No. (A8-BR-Rac) Cu.sub.2O NH.sub.3 .Math. H.sub.2O NMP Temp./Time (B)-Rac 11D-1 3.00 g 0.96 g 7.5 mL 3 mL 105-115° C./21 h 91.85 (0.51 eq.) (2.5 v) (1 v) 11D-2 3.00 g 0.96 g 10.5 mL 3 mL 105-115° C./21 h 92.93 (0.51 eq.) (3.5 v) (1 v)

[0296] In the table, (B)-Rac means a racemic compound represented by Formula (B).

Example 11E

[0297] (R)-8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol (Formula (A8-BR)) (3.00 g) obtained by an enzymatic reduction in the same manner as in the methods of Example 10A to Example 10D, Cu.sub.2O (0.96 g, 0.51 eq), NMP (3 mL, 1 v), and ammonia water (10.5 mL, 3.5 v) were mixed in a sealed-tube reactor, and a sealed-tube reaction was performed at a temperature of 105° C. to 115° C. for 21 hours (some parts of the reaction solution were sampled and subjected to HPLC analysis, and it was confirmed that an IPC yield was 92.93%). After cooling the reaction solution, an aqueous solution of 25 wt % sodium chloride (23 mL) and 2-methyltetrahydrofuran (2-MeTHF) (15 mL) were added to the reaction solution and the mixed solution was filtered, then the filtered material was washed with 2-MeTHF (15 mL). The aqueous layer and the organic layer were separated, and the aqueous layer was extracted with 2-MeTHF (15 mL, 4 times), then the organic layer was combined with the previously obtained organic layer, washed with an aqueous solution of 10 wt % Na.sub.2SO.sub.4 (15 mL), then decolorized through a CUNO (trademark) (filter) over 1 hour. The CUNO was washed with 2-MeTHF (15 mL), and the solvent was concentrated, then isopropyl acetate (6 mL) was added, and n-heptane (1.5 mL) was added dropwise at a temperature of 30° C. to 40° C., and the mixture was stirred at the same temperature for 0.5 hours. Furthermore, n-heptane (10.5 mL) was added dropwise, and the mixture was stirred at a temperature of 30° C. to 40° C. for 0.5 hours. Furthermore, n-heptane (3.0 mL) was added dropwise, and the mixture was stirred at a temperature of 30° C. to 40° C. for 0.5 hours. Furthermore, n-heptane (3.0 mL) was added dropwise, and the mixture was stirred at a temperature of 30° C. to 40° C. for 0.5 hours. The mixed solution described above was cooled at 20° C. for 30 minutes and stirred at a temperature of 15° C. to 25° C. for 1 hour. The mixed solution was filtered, and the filtered material was washed with n-heptane (3 mL) and dried to obtain the title compound (1.375 g, 60.1%).

Example 11F

[0298] (R)-8-bromo-1,2,3,4-tetrahydronaphthalen-2-ol (Formula (A8-BR)) (16.32 g, NMP solution, content 61.1%) obtained by an enzymatic reduction in the same manner as in the methods of Example 10A to Example 10D, Cu.sub.2O (3.18 g, 0.51 eq), NMP (5 mL, 0.5 v), and ammonia water (35 mL, 3.5 v) were mixed in a sealed-tube reactor, and a sealed-tube reaction was performed at a temperature of 105° C. to 115° C. for 40 hours (it was confirmed that an IPC yield at 40 hours was 90.16%). After cooling the reaction solution, an aqueous solution of 25 wt % sodium chloride (75 mL) and 2-MeTHF (50 mL) were added to the reaction solution, and the mixed solution was filtered using diatomite (diatomaceous earth) (20.00 g), then the filtered material (cake) was

washed with 2-MeTHF (50 mL). The aqueous layer and the organic layer were separated, and the aqueous layer was extracted with 2-MeTHF (50 mL, 2 times), then the organic layer was combined with the previously obtained organic layer, washed with an aqueous solution of 8 wt % Na.sub.2SO.sub.4 (50 mL, 2 times), and the organic layer (92.5% of a total amount) was taken out, then an aqueous solution of 0.5 M hydrochloric acid (111 mL) was added dropwise at 5° C. to 15° C. (in this case, pH=1.2). The aqueous layer and the organic layer were separated, and the aqueous layer was extracted with 2-MeTHF (30 mL). An aqueous solution of 10% sodium hydroxide (22 mL) was added to the aqueous layer, and the aqueous layer was extracted with 2-MeTHF (100 mL, 50 mL, 50 mL). After combining with the previously obtained organic layer, the organic layer was concentrated at 40C or lower, and n-heptane (80 mL) was added dropwise at 35° C. to 45° C., then the mixture was cooled to 5° C. Thereafter, the mixture was stirred at 0° C. to 10° C. for 24 hours and collected by filtration, and the filtered material was washed with n-heptane (10 mL) and dried to obtain the title compound (4.50 g, 67.8%, optical purity 99.9%).

Example 11G

[0299] The sealed-tube reaction was performed under conditions shown in the table below.

TABLE-US-00029 TABLE 29 Reaction IPC (%) Reagent (eq.) Condition @7.34 min Ex. (A8-BR) Cu.sub.2O NH.sub.3 .Math. H.sub.2O NMP Temp./Time (B) 11G-1 72.44 g 14.56 g 162 mL 23 mL 105-115° C./20 h 90.87 (NMP (0.50 eq.) (3.5 v) (0.5 v) solution, content 63.8%) 11G-2 78.39 g 15.78 g 175 mL 25 mL 105-115° C./20 h 89.60 (NMP (0.50 eq.) (3.5 v) (0.5 v) solution, content 63.8%)

(Work up 11G-1)

[0300] After the reaction of Example 11G-1 was completed and the reaction solution was cooled, an aqueous solution of 25 wt % sodium chloride (345 mL) and 2-MeTHF (250 mL) were added to the reaction solution, and the mixed solution was filtered using diatomite, then the filtered material (cake) was washed with 2-MeTHF (230 mL). The aqueous layer and the organic layer were separated, and the aqueous layer was extracted with 2-MeTHF (230 mL, 2 times), then the organic layer was combined with the previously obtained organic layer to obtain the organic phase (11G-1).

(Work up 11G-2)

[0301] After the reaction of Example 11G-2 was completed and the reaction solution was cooled, an aqueous solution of 25 wt % sodium chloride (375 mL) and 2-MeTHF (250 mL) were added to the reaction solution, and the mixed solution was filtered using diatomite, then the filtered material (cake) was washed with 2-MeTHF (250 mL). The aqueous layer and the organic layer were separated, and the aqueous layer was extracted with 2-MeTHF (250 mL, 2 times), then the organic layer was combined with the previously obtained organic layer to obtain the organic phase (11G-2).

(Work up 11G-3)

[0302] After mixing the previously obtained organic phase (11G-1) and organic phase (11G-2), the mixture was washed with an aqueous solution of 8 wt % Na.sub.2SO.sub.4(480 mL, 2 times), then an aqueous solution of 0.5 M hydrochloric acid (1,156 mL) was added dropwise, and a pH was adjusted to 0.88. The aqueous layer and the organic layer were separated, and the aqueous layer was extracted with 2-MeTHF (290 mL). An aqueous solution of 10% sodium hydroxide (230 mL) was added to the aqueous layer, and the aqueous layer was extracted with 2-MeTHF (1,000 mL, 500 mL, 500 mL, 3 times). After combining with the previously obtained organic layer, the organic layer was concentrated at 40° C. or lower, and n-heptane (576 mL) was added dropwise at 35° C. to 45° C., and then the mixture was cooled to 0° C. to 10° C., stirred at the same temperature, collected by filtration, and the filtered material was washed with n-heptane (96 mL) and dried to obtain the title compound (53.55 g, 70.8%, optical purity 99.9%).

Data of physical properties of Formula (B)

[0303] (.sup.1H-NMR, 400 MHz, manufacturer: Bruker, CDCl.sub.3, δ ppm)

[0304] 6.91 (1H, t, J=7 Hz), 6.52-6.46 (2H, m), 4.19-4.04 (2H, m), 3.51 (1H, brs), 2.93-2.65 (3H, m), 2.31 (1H, dd, J=7.16 Hz), 2.02-1.89 (1H, m), 1.85-1.65 (1H, m)

[0305] The ammonia water used in (Example 11A) to (Example 11G) is 25% to 28% ammonia water.

(Example 12A) to (Example 12B) Synthesis of (E)-2-(7-trifluoromethylchroman-4-ylidene)-N-[(7R)-7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl]acetamide

##STR00067##

Example 12A

[0306] A condensation reaction (reaction conditions: 20° C. to 25° C., stirring for 17 hours) was performed using (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (3 g) obtained in the same operation as that in (Example 11G), (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (4.83 g, 1.0 eq) obtained by a production method disclosed in WO 2007/010383, isopropanol (60.01 g: 20 times its weight with respect to the compound represented by Formula (B)), and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (6.67 g, 1.3 eq). After adding water (75 mL) to the reaction solution, the mixed solution was cooled to 10° C. to 15° C., stirred at the same temperature for 1 hour, filtered, and the filtered material was washed with water and dried at 36° C. for 16 hours. 2-MeTHF (90 g) was added to the obtained filtered material, and the mixture was stirred at 70° C. to 80° C. for 0.5 hours, then the solution was concentrated under reduced pressure at 40° C. or lower until a volume of the solution was 6 mL. Subsequently, after stirring the concentrated solution at 70° C. to 80° C. for 1 hour, it was cooled to 0° C. to 5° C., and 60 g of n-heptane was added dropwise at the same temperature, then the mixture was further stirred at the same temperature for 30 minutes. The mixture was collected by filtration, and the filtered material was washed with n-heptane (9 g), and dried to obtain the title compound (5.96 g, optical purity 99.9%).

(Example 12B) [Scale-up]

[0307] A condensation reaction (reaction conditions: 20° C. to 25° C., stirring for 13 hours) was performed using (R)-8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (44.5 g) obtained in the same operation as that in (Example 11G), (E)-2-(7-(trifluoromethyl)chroman-4-ylidene)acetic acid (72.5 g, 1.0 eq) obtained by a production method disclosed in WO 2007/010383, isopropanol (900 g: 18 times its weight with respect to the compound represented by Formula (B)), and 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) (100.05 g, 1.3 eq). A work up was performed according to (Example 12a), and thereby the title compound (95.7 g, optical purity 100%) was obtained.

[Data of Physical Properties of Compound Represented by Formula (I)]

[0308] (.sup.1H-NMR data (CDCl.sub.3) (δ: ppm)):

[0309] 7.80-7.58 (m, 1H), 7.24-6.92 (m, 5H), 6.45 (s, 1H), 4.29 (t, 2H, J=6 Hz), 4.28-4.15 (m, 1H), 3.51 (t, 2H, J=5 Hz), 3.10-2.78 (m, 3H), 2.69-2.53 (m, 1H), 2.14-2.00 (m, 1H), 1.90-1.67 (m, 2H)

(LC-MS):

[0310] RT=4.73 (minutes), [M+H].sup.+=404

[0311] An optical purity of the compound represented by Formula (I) was measured using a HPLC LC-VP system of Shimadzu Corporation under the following conditions.

TABLE-US-00030 TABLE 30 Column CHIRALCEL AD-H ID 4.6 × 250 mm (Daicel) Elution solvent Ethanol Flow rate 0.5 mL/min Column temperature 40° C. Measurement 254 nm wavelength Elution time Compound represented by (I) - 10.5 minutes, Enantiomer of compound represented by (I) - 18.6 minutes

Explanation of References

[0312] L**1**, L**2**, L**3**, L**4**: Nitrogen inlet [0313] M**1**: Vessel containing raw material, TEMPO, and dichloromethane [0314] M**2**: Vessel containing KBr, NaHCO.sub.3, and water [0315] M**3**: Vessel containing NaClO [0316] P**1**, P**2**, P**3**: Pump [0317] T**1**, T**2**, T**3**: Pre-cooling tube [0318] S**1**, S**2**, S**3**: Stirrer [0319] R**1**, R**2**, R**3**: Reactor [0320] CD: Recovery drum

Claims

1. A method for producing a compound represented by Formula (I), the method comprising: deprotecting a tert-butoxycarbonyl group of a compound represented by Formula (A-7) to obtain a compound represented by Formula (B) or a salt thereof; and causing a condensation reaction of the compound represented by Formula (B) or a salt thereof and a compound represented by Formula (CA-1) using 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMT-MM) as a condensation agent to obtain the compound represented by Formula (I), ##STR00068##

2. The method for producing a compound represented by Formula (I) according to claim 1, further comprising: asymmetrically reducing a compound represented by Formula (A-6) to obtain the compound represented by Formula (A-7), ##STR00069##

3. The method for producing a compound represented by Formula (I) according to claim 2, further comprising: causing an oxidation reaction of a compound represented by Formula (A-5) to obtain the compound represented by Formula (A-6), ##STR00070##

4. The method for producing a compound represented by Formula (I) according to claim 3, further comprising: tert-butoxycarbonylating an amino group of a compound represented by Formula (A) to obtain the compound represented by Formula (A-5), ##STR00071##

5. A method for producing a compound represented by Formula (B), the method comprising: asymmetrically reducing a compound represented by Formula (A-6) to obtain a compound represented by Formula (A-7), and deprotecting a tert-butoxycarbonyl group of a compound represented by Formula (A-7) to obtain the compound represented by Formula (B) or a salt thereof, ##STR00072##

6. The method for producing a compound represented by Formula (B) according to claim 5, further comprising: causing an oxidation reaction of a compound represented by Formula (A-5) to obtain the compound represented by Formula (A-6), ##STR00073##

7. The method for producing a compound represented by Formula (B) according to claim 6, further comprising: tert-butoxycarbonylating an amino group of a compound represented by Formula (A) to obtain the compound represented by Formula (A-5), ##STR00074##

8. A method for producing a compound represented by Formula (A-7), the method comprising: asymmetrically reducing a compound represented by Formula (A-6) to obtain the compound represented by Formula (A-7), ##STR00075##

9. The method for producing a compound represented by Formula (A-7) according to claim 8, further comprising: causing an oxidation reaction of a compound represented by Formula (A-5) to obtain the compound represented by Formula (A-6), ##STR00076##