

Description

Title of Invention: NOVEL METHOD FOR PRODUCING ANTIBODY-
DRUG CONJUGATE

Technical Field

[0001]

The present invention relates to a novel method for producing exatecan, which is a component of an antibody-drug conjugate, and a novel method for producing an antibody-drug conjugate wherein the aforementioned method is used.

Background Art

[0002]

An antibody-drug conjugate (ADC) having a drug with cytotoxicity conjugated to an antibody, whose antigen is expressed on the surface of cancer cells and which also binds to an antigen capable of cellular internalization, and therefore can deliver the drug selectively to cancer cells, is thus expected to cause accumulation of the drug within cancer cells and to kill the cancer cells (Non-Patent Literatures 1 to 5).

[0003]

As one such antibody-drug conjugate, an antibody-drug conjugate comprising an antibody and exatecan, which is a topoisomerase I inhibitor, as its components is

known (Patent Literatures 1 to 8 and Non-Patent Literatures 6 and 7). Since these antibody-drug conjugates exert a particularly superior antitumor effect and safety, they are currently under clinical studies.

[0004]

The methods described in Patent Literatures 9 to 11 are known as methods for producing exatecan.

Citation List

Patent Literatures

[0005]

Patent Literature 1: International Publication No. WO 2014/057687

Patent Literature 2: International Publication No. WO 2014/061277

Patent Literature 3: International Publication No. WO 2015/098099

Patent Literature 4: International Publication No. WO 2015/115091

Patent Literature 5: International Publication No. WO 2015/146132

Patent Literature 6: International Publication No. WO 2015/155976

Patent Literature 7: International Publication No. WO 2015/155998

Patent Literature 8: International Publication No. WO 2018/135501

Patent Literature 9: Japanese Patent Laid-Open No. 5-59061

Patent Literature 10: Japanese Patent Laid-Open No. 8-337584

Patent Literature 11: International Publication No. WO 96/26181

Non-Patent Literatures

[0006]

Non-Patent Literature 1: Ducry, L., et al., Bioconjugate Chem. (2010) 21, 5-13.

Non-Patent Literature 2: Alley, S. C., et al., Current Opinion in Chemical Biology (2010) 14, 529-537.

Non-Patent Literature 3: Damle N. K. Expert Opin. Biol. Ther. (2004) 4, 1445-1452.

Non-Patent Literature 4: Senter P. D., et al., Nature Biotechnology (2012) 30, 631-637.

Non-Patent Literature 5: Howard A. et al., J Clin Oncol 29: 398-405.

Non-Patent Literature 6: Ogitani Y. et al., Clinical Cancer Research (2016) 22(20), 5097-5108.

Non-Patent Literature 7: Ogitani Y. et al., Cancer Science (2016) 107, 1039-1046.

Summary of Invention

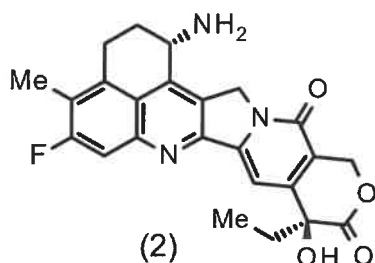
Technical Problem

[0007]

Exatecan is the compound represented by formula (2):

[0008]

[Chem. 1]



[0009]

and is a compound that serves as a component of the antibody-drug conjugate according to the present invention.

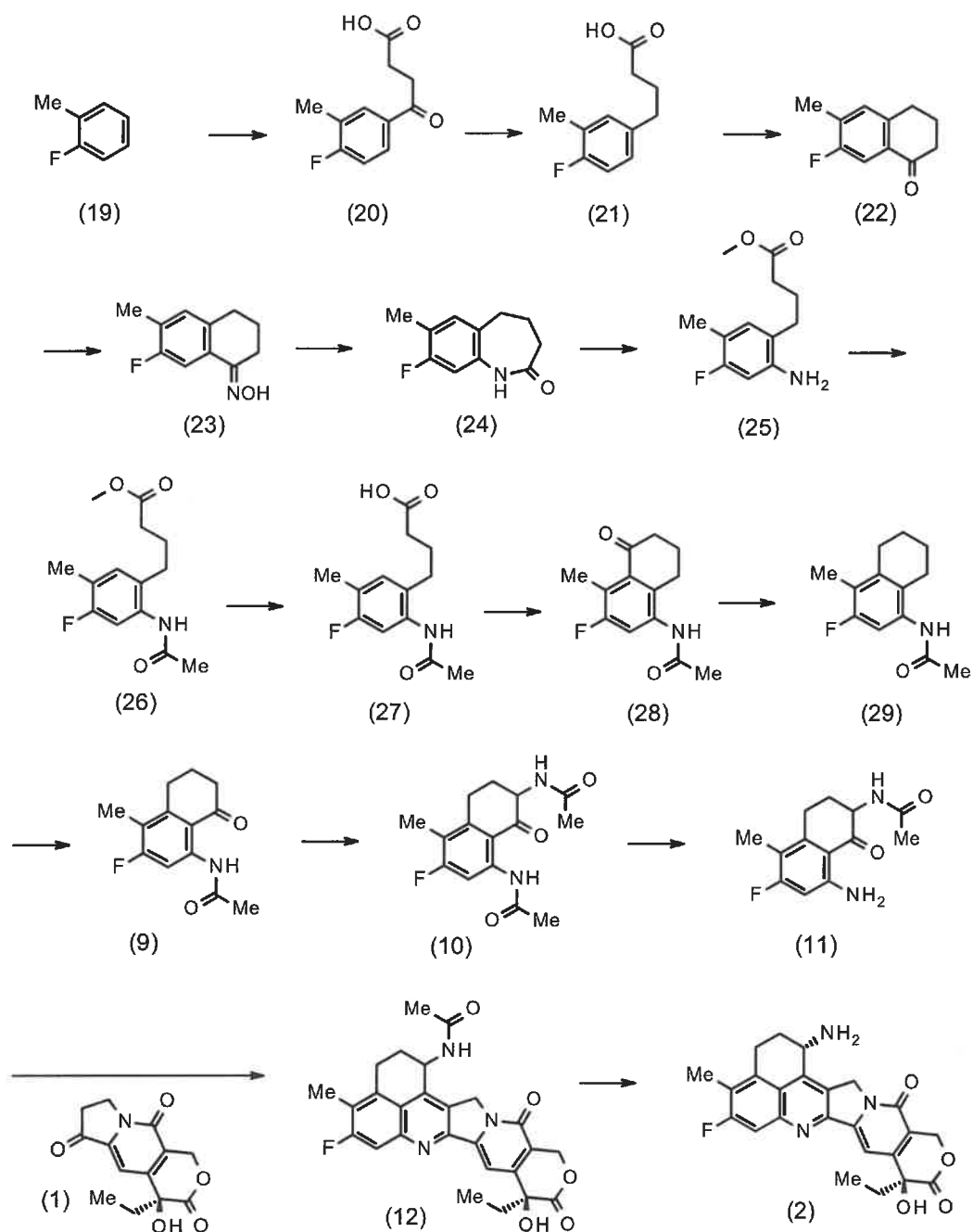
[0010]

The methods described in Patent Literatures 9 to 11 are known as methods for producing exatecan. Such production methods can be described as follows. That is to say, such production methods comprise reacting a compound represented by formula (19) with succinic anhydride to convert the compound into a compound represented by formula (20), reducing the compound to convert the compound into a compound represented by formula (21), converting the compound into a compound represented by formula (22) by an intramolecular cyclization reaction, converting the compound into a compound represented by formula (23) by oximation, converting the compound into a compound represented by formula (24) by Beckmann rearrangement, converting the compound into a compound represented by formula (25) by a

ring opening reaction, protecting the amino group to convert the compound into a compound represented by formula (26), hydrolyzing the compound to convert the compound into a compound represented by formula (27), converting the compound into a compound represented by formula (28) by an intramolecular cyclization reaction, converting the compound into a compound represented by formula (29) by reduction, converting the compound into a compound represented by formula (9) by oxidation, then introducing a nitrogen atom to convert the compound into a compound represented by formula (10), converting the compound into a compound represented by formula (11) by selective deprotection, converting the compound into a compound represented by formula (12) by a Friedlander reaction with a compound represented by formula (1), and, finally, deprotecting the acetyl group to produce a compound represented by formula (2), i.e., exatecan. However, in this production method, the ring-opening and ring-closing reactions and the oxidation and reduction reactions have to be repeatedly performed, thus the number of steps is large, and complex operations are required. Accordingly, development of an industrially superior production method is desired.

[0011]

[Chem. 2]



[0012]

An object of the present invention is to find a novel, industrially superior method for producing exatecan, wherein the number of steps is small. Moreover, another object of the present invention is to develop a

novel method for producing an antibody-drug conjugate wherein the aforementioned method is used.

Solution to Problem

[0013]

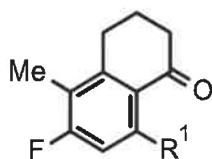
As a result of having conducted diligent research on a method for producing exatecan, the present inventors found a novel, industrially superior method for producing exatecan, wherein the number of steps is small. Moreover, the inventors developed a novel method for producing an antibody-drug conjugate wherein exatecan produced by the aforementioned production method is used.

Specifically, the present invention relates to the following.

[1] A method for producing a compound represented by formula (C):

[0014]

[Chem. 4]



(C)

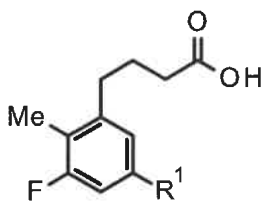
[0015]

wherein R¹ represents an amino group protected with a protecting group,

the method comprising a step of subjecting a compound represented by formula (B):

[0016]

[Chem. 3]



(B)

[0017]

wherein R¹ represents the same meaning as above, to intramolecular cyclization to convert the compound represented by formula (B) into the compound represented by formula (C).

[2] The production method according to [1], wherein R¹ is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[3] The production method according to [1], wherein R¹ is an amino group protected with an acetyl group or a trifluoroacetyl group.

[4] The production method according to [1], wherein R¹ is an amino group protected with an acetyl group.

[5] The production method according to any one of [1] to [4], wherein the intramolecular cyclization is performed by a method comprising reacting the compound represented by formula (B) with trifluoroacetic anhydride.

[6] The production method according to [5], wherein the intramolecular cyclization is performed in a solvent comprising trifluoroacetic acid.

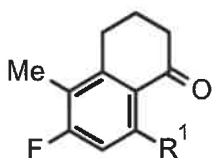
[7] The production method according to any one of [1] to [4], wherein the intramolecular cyclization is performed by a method comprising reacting the compound represented by formula (B) with thionyl chloride.

[8] The production method according to [7], wherein the intramolecular cyclization is performed in the presence of aluminium chloride.

[9] A method for producing a compound represented by formula (C):

[0018]

[Chem. 6]



(C)

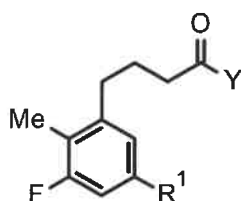
[0019]

wherein R¹ represents an amino group protected with a protecting group,

the method comprising a step of subjecting a compound represented by formula (J):

[0020]

[Chem. 5]



(J)

[0021]

wherein Y represents a leaving group, and R¹ represents the same meaning as above, to intramolecular cyclization to convert the compound represented by formula (J) into the compound represented by formula (C).

[10] The production method according to [9], wherein R¹ is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[11] The production method according to [9], wherein R¹ is an amino group protected with an acetyl group or a trifluoroacetyl group.

[12] The production method according to [9], wherein R¹ is an amino group protected with an acetyl group.

[13] The production method according to any one of [9] to [12], wherein Y is a chloro group.

[14] The production method according to any one of [9] to [12], wherein Y is a trifluoroacetoxy group.

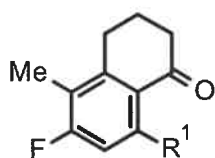
[15] The production method according to [13], wherein the intramolecular cyclization is performed in the presence of aluminium chloride.

[16] The production method according to [14], wherein the intramolecular cyclization is performed in a solvent comprising trifluoroacetic acid.

[17] A method for producing a compound represented by formula (C):

[0022]

[Chem. 10]



(C)

[0023]

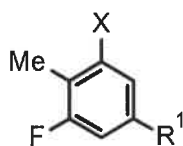
wherein R¹ represents an amino group protected with a protecting group,

the method comprising the steps of:

coupling a compound represented by formula (D):

[0024]

[Chem. 7]



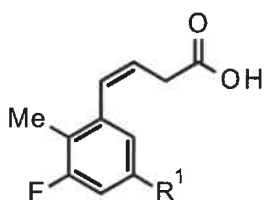
(D)

[0025]

wherein X represents a leaving group, and R¹ represents the same meaning as above, with 3-butenic acid to convert the compound represented by formula (D) into a compound represented by formula (E):

[0026]

[Chem. 8]



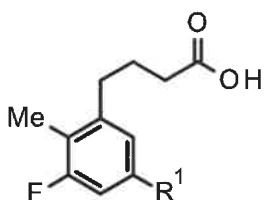
(E)

[0027]

wherein R¹ represents the same meaning as above; then
reducing the compound represented by formula (E) to
convert the compound represented by formula (E) into a
compound represented by formula (B):

[0028]

[Chem. 9]



(B)

[0029]

wherein R¹ represents the same meaning as above; and then
subjecting the compound represented by formula (B)
to intramolecular cyclization to convert the compound
represented by formula (B) into the compound represented
by formula (C).

[18] The production method according to [17], wherein X
is a bromo group, an iodo group, a

trifluoromethanesulfonyloxy group, or an arylsulfonyloxy group.

[19] The production method according to [17], wherein X is a bromo group.

[20] The production method according to [17], wherein X is an iodo group.

[21] The production method according to any one of [17] to [20], wherein R¹ is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[22] The production method according to any one of [7] to [10], wherein R¹ is an amino group protected with an acetyl group or a trifluoroacetyl group.

[23] The production method according to any one of [17] to [20], wherein R¹ is an amino group protected with an acetyl group.

[24] The production method according to any one of [17] to [23], wherein the step of coupling the compound represented by formula (D) with 3-butenic acid to convert the compound represented by formula (D) into the compound represented by formula (E) is performed in the presence of a palladium complex prepared from palladium(II) acetate and tri(o-tolyl)phosphine.

[25] The production method according to any one of [17] to [24], comprising the steps of: dissolving the compound represented by formula (E) in a basic aqueous solution to

wash the compound represented by formula (E) with a first organic solvent and separating the solvents; and then adding an acid to the basic aqueous solution to extract the compound represented by formula (E) with a second organic solvent and separating the solvents.

[26] The production method according to [25], wherein the first organic solvent is 2-methyltetrahydrofuran.

[27] The production method according to [25] or [26], wherein the second organic solvent is 2-methyltetrahydrofuran.

[28] The production method according to any one of [25] to [27], wherein the basic aqueous solution is an aqueous sodium hydroxide solution.

[29] The production method according to any one of [17] to [28], wherein the step of reducing the compound represented by formula (E) to convert the compound represented by formula (E) into the compound represented by formula (B) is performed by a method comprising reacting the compound represented by formula (E) with hydrogen in a solvent in the presence of a palladium carbon catalyst.

[30] The production method according to any one of [17] to [29], wherein the step of subjecting the compound represented by formula (B) to intramolecular cyclization to convert the compound represented by formula (B) into the compound represented by formula (C) is performed by a

method comprising reacting the compound represented by formula (B) with trifluoroacetic anhydride.

[31] The production method according to [30], wherein the intramolecular cyclization is performed in a solvent comprising trifluoroacetic acid.

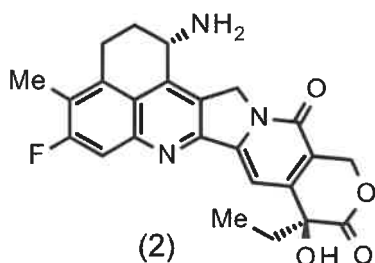
[32] The production method according to any one of [17] to [29], wherein the step of subjecting the compound represented by formula (B) to intramolecular cyclization to convert the compound represented by formula (B) into the compound represented by formula (C) is performed by a method comprising reacting the compound represented by formula (B) with thionyl chloride.

[33] The production method according to [32], wherein the intramolecular cyclization is performed in the presence of aluminium chloride.

[34] A method for producing a compound represented by formula (2):

[0030]

[Chem. 16]



[0031]

wherein a compound represented by formula (C):

[0032]

[Chem. 11]



(C)

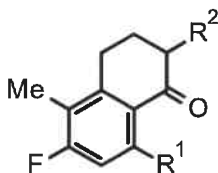
[0033]

produced by the method according to any one of [1] to [33] is used as a starting material, the method comprising the steps of:

converting the compound represented by formula (C) into a compound represented by formula (F):

[0034]

[Chem. 12]



(F)

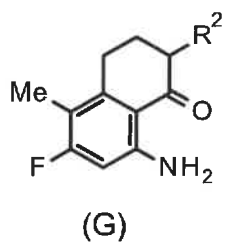
[0035]

wherein R¹ represents the same meaning as defined in any one of claims 1 to 33, and R² represents an amino group protected with a protecting group; then

converting the compound represented by formula (F) into a compound represented by formula (G):

[0036]

[Chem. 13]



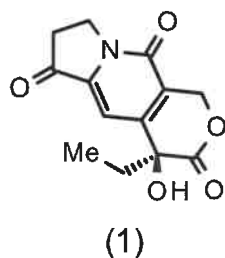
[0037]

wherein R^2 represents the same meaning as above; then

condensing the compound represented by formula (G) with a compound represented by formula (1):

[0038]

[Chem. 14]

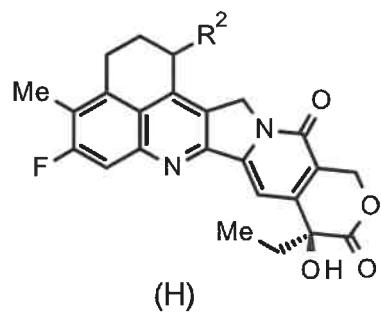


[0039]

to convert the compound represented by formula (G) into a compound represented by formula (H):

[0040]

[Chem. 15]



[0041]

wherein R^2 represents the same meaning as above; and then

converting the compound represented by formula (H) into the compound represented by formula (2).

[35] The production method according to [34], wherein R^2 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[36] The production method according to [34], wherein R^2 is an amino group protected with an acetyl group or a trifluoroacetyl group.

[37] The production method according to [34], wherein R^2 is an amino group protected with an acetyl group.

[38] The production method according to any one of [34] to [37], wherein the step of converting the compound represented by formula (C) into the compound represented by formula (F) comprises the sub-steps of: (i) reacting the compound represented by formula (C) with a nitrous acid ester in the presence of a base to introduce a nitroso group; (ii) introducing a protecting group to a nitrogen atom derived from the nitroso group; and (iii) reducing the compound represented by formula (C) with hydrogen in the presence of a platinum carbon catalyst.

[39] The production method according to any one of claims [34] to [38], wherein the step of converting the compound represented by formula (F) into the compound represented

by formula (G) is performed in a solvent comprising hydrochloric acid/ethanol.

[40] The production method according to any one of claims [34] to [39], wherein the step of condensing the compound represented by formula (G) with the compound represented by formula (1) to convert the compound represented by formula (G) into the compound represented by formula (H) is performed in a solvent comprising o-cresol.

[41] The production method according to any one of [34] to [40], wherein the step of converting the compound represented by formula (H) into the compound represented by formula (2) is performed in a solvent comprising methanesulfonic acid.

[42] The production method according to any one of [34] to [41], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt.

[43] The production method according to any one of [34] to [41], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt m-hydrate wherein m is in a range of 0 to 3.

[44] The production method according to any one of [34] to [41], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt anhydrate.

[45] The production method according to any one of [34] to [41], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt monohydrate.

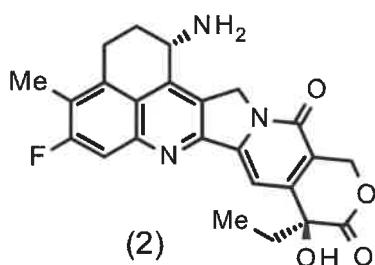
[46] The production method according to any one of [34] to [41], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt dihydrate.

[47] The production method according to any one of [34] to [41], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt trihydrate.

[48] A method for producing a compound represented by formula (2):

[0042]

[Chem. 28]



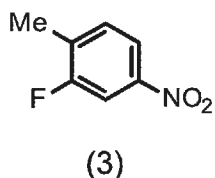
[0043]

wherein the method comprises the steps of:

converting a compound represented by formula (3):

[0044]

[Chem. 17]

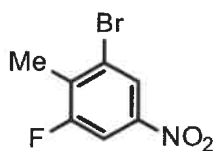


[0045]

into a compound represented by formula (4):

[0046]

[Chem. 18]



(4)

[0047]

; then

converting the compound represented by formula (4)
into a compound represented by formula (5):

[0048]

[Chem. 19]



(5)

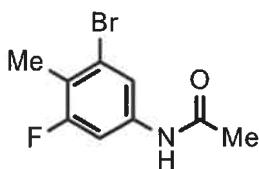
[0049]

; then

converting the compound represented by formula (5)
into a compound represented by formula (6):

[0050]

[Chem. 20]



(6)

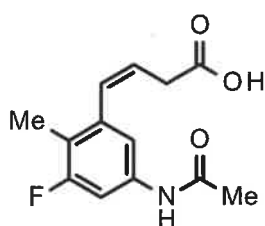
[0051]

; then

coupling the compound represented by formula (6) with 3-butenic acid to convert the compound represented by formula (6) into a compound represented by formula (7):

[0052]

[Chem. 21]



(7)

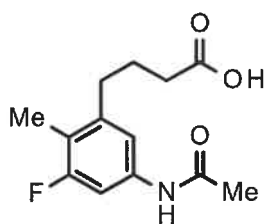
[0053]

; then

converting the compound represented by formula (7) into a compound represented by formula (8):

[0054]

[Chem. 22]



(8)

[0055]

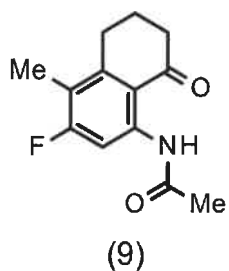
; then

subjecting the compound represented by formula (8) to intramolecular cyclization to convert the compound

represented by formula (8) into a compound represented by formula (9):

[0056]

[Chem. 23]



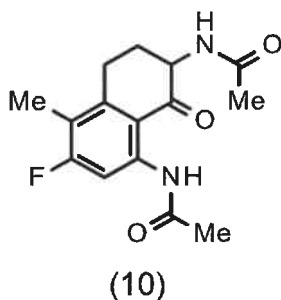
[0057]

; then

converting the compound represented by formula (9) into a compound represented by formula (10):

[0058]

[Chem. 24]



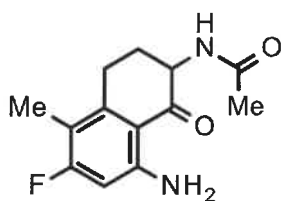
[0059]

; then

converting the compound represented by formula (10) into a compound represented by formula (11):

[0060]

[Chem. 25]



(11)

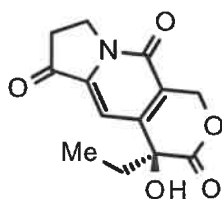
[0061]

; then

condensing the compound represented by formula (11) with a compound represented by formula (1):

[0062]

[Chem. 26]



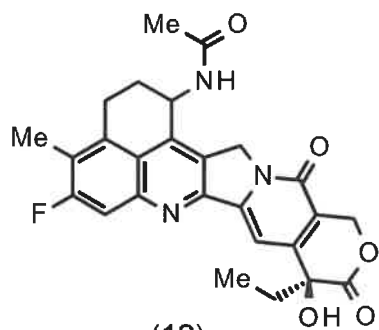
(1)

[0063]

to convert the compound represented by formula (11) into a compound represented by formula (12):

[0064]

[Chem. 27]



(12)

[0065]

; and then

converting the compound represented by formula (12) into the compound represented by formula (2).

[49] The production method according to [48], wherein the step of coupling the compound represented by formula (6) with 3-butenic acid to convert the compound represented by formula (6) into the compound represented by formula (7) is performed in the presence of a palladium complex prepared from palladium(II) acetate and tri(o-tolyl)phosphine.

[50] The production method according to [48] or [49], comprising the steps of: dissolving the compound represented by formula (7) in a basic aqueous solution to wash the compound represented by formula (7) with a first organic solvent and separating the solvents; and then adding an acid to the basic aqueous solution to extract the compound represented by formula (7) with a second organic solvent and separating the solvents.

[51] The production method according to [50], wherein the first organic solvent is 2-methyltetrahydrofuran.

[52] The production method according to [50] or [51], wherein the second organic solvent is 2-methyltetrahydrofuran.

[53] The production method according to any one of [50] to [52], wherein the basic aqueous solution is an aqueous sodium hydroxide solution.

[54] The production method according to any one of [50] to [53], wherein the step of subjecting the compound represented by formula (8) to intramolecular cyclization to convert the compound represented by formula (8) into the compound represented by formula (9) is performed by a method comprising reacting the compound represented by formula (8) with trifluoroacetic anhydride.

[55] The production method according to [54], wherein the intramolecular cyclization is performed in a solvent comprising trifluoroacetic acid.

[56] The production method according to any one of [48] to [55], wherein the step of converting the compound represented by formula (9) into the compound represented by formula (10) comprises the sub-steps of: (i) reacting the compound represented by formula (9) with a nitrous acid ester in the presence of a base to introduce a nitroso group; then (ii) introducing a protecting group to a nitrogen atom derived from the nitroso group; and (iii) reducing the compound represented by formula (9) with hydrogen in the presence of a platinum carbon catalyst.

[57] The production method according to any one of [48] to [56], wherein the step of converting the compound represented by formula (10) into the compound represented by formula (11) is performed in a solvent comprising hydrochloric acid/ethanol.

[58] The production method according to any one of [48] to [57], wherein the step of condensing the compound represented by formula (11) with the compound represented by formula (1) to convert the compound represented by formula (11) into the compound represented by formula (12) is performed in a solvent comprising o-cresol.

[59] The production method according to any one of [48] to [58], wherein the step of converting the compound represented by formula (12) into the compound represented by formula (2) is performed in a solvent comprising methanesulfonic acid.

[60] The production method according to any one of [48] to [59], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt.

[61] The production method according to any one of [48] to [59], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt m-hydrate wherein m is in a range of 0 to 3.

[62] The production method according to any one of [48] to [59], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt anhydrate.

[63] The production method according to any one of [48] to [59], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt monohydrate.

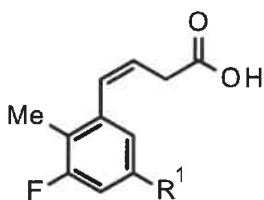
[64] The production method according to any one of [48] to [59], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt dihydrate.

[65] The production method according to any one of [48] to [59], wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt trihydrate.

[66] A method for producing a compound represented by formula (E):

[0066]

[Chem. 30]



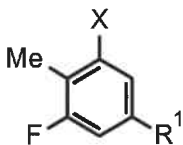
(E)

[0067]

wherein R¹ represents an amino group protected with a protecting group, the method comprising a step of coupling a compound represented by formula (D):

[0068]

[Chem. 29]



(D)

[0069]

wherein X represents a leaving group, and R¹ represents the same meaning as above, with 3-butenic acid to convert the compound represented by formula (D) into the compound represented by formula (E).

[67] The production method according to [66], wherein X is a bromo group, an iodo group, a trifluoromethanesulfonyloxy group, or an arylsulfonyloxy group.

[68] The production method according to [66], wherein X is a bromo group.

[69] The production method according to [66], wherein X is an iodo group.

[70] The production method according to any one of [66] to [69], wherein R^1 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[71] The production method according to any one of [66] to [69], wherein R^1 is an amino group protected with an acetyl group or a trifluoroacetyl group.

[72] The production method according to any one of [66] to [69], wherein R^1 is an amino group protected with an acetyl group.

[73] The production method according to any one of [66] to [72], which is performed in the presence of a palladium complex prepared from palladium(II) acetate and tri(o-tolyl)phosphine.

[74] The production method according to any one of [66] to [73], comprising the steps of: dissolving the compound represented by formula (E) in a basic aqueous solution to wash the compound represented by formula (E) with a first

organic solvent and separating the solvents; and then adding an acid to the basic aqueous solution to extract the compound represented by formula (E) with a second organic solvent and separating the solvents.

[75] The production method according to [74], wherein the first organic solvent is 2-methyltetrahydrofuran.

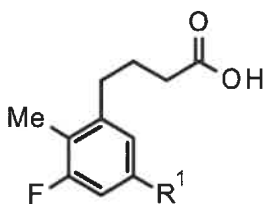
[76] The production method according to [74] or [75], wherein the second organic solvent is 2-methyltetrahydrofuran.

[77] The production method according to any one of [74] to [76], wherein the basic aqueous solution is an aqueous sodium hydroxide solution.

[78] A method for producing a compound represented by formula (B):

[0070]

[Chem. 32]



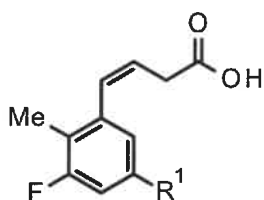
(B)

[0071]

wherein R¹ represents an amino group protected with a protecting group, the method comprising a step of reducing a compound represented by formula (E):

[0072]

[Chem. 31]



(E)

[0073]

wherein R¹ represents the same meaning as above, to convert the compound represented by formula (E) into the compound represented by formula (B).

[79] The production method according to [78], wherein R¹ is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[80] The production method according to [78], wherein R¹ is an amino group protected with an acetyl group or a trifluoroacetyl group.

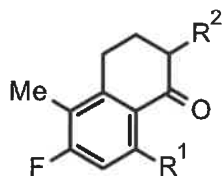
[81] The production method according to [78], wherein R¹ is an amino group protected with an acetyl group.

[82] The production method according to any one of [78] to [81], which is performed by a method comprising reacting the compound represented by formula (E) with hydrogen in a solvent in the presence of a palladium carbon catalyst.

[83] A method for producing a compound represented by formula (F):

[0074]

[Chem. 34]



(F)

[0075]

wherein R¹ represents an amino group protected with a protecting group, R² represents an amino group protected with a protecting group, the method comprising a step of converting a compound represented by formula (C):

[0076]

[Chem. 33]



(C)

[0077]

wherein R¹ represents the same meaning as above, into a compound represented by formula (F), wherein the step comprises the sub-steps of: (i) reacting the compound represented by formula (C) with a nitrous acid ester in the presence of a base to introduce a nitroso group; (ii) introducing a protecting group to a nitrogen atom derived from the nitroso group; and (iii) reducing the compound represented by formula (C) with hydrogen in the presence of a platinum carbon catalyst.

[84] The production method according to [83], wherein R^1 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[85] The production method according to [83], wherein R^1 is an amino group protected with an acetyl group or a trifluoroacetyl group.

[86] The production method according to [83], wherein R^1 is an amino group protected with an acetyl group.

[87] The production method according to any one of [83] to [86], wherein R^2 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

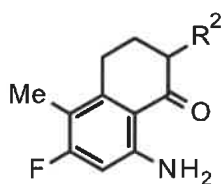
[88] The production method according to any one of [83] to [86], wherein R^2 is an amino group protected with an acetyl group or a trifluoroacetyl group.

[89] The production method according to any one of [83] to [86], wherein R^2 is an amino group protected with an acetyl group.

[90] A method for producing a compound represented by formula (G):

[0078]

[Chem. 36]



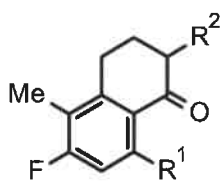
(G)

[0079]

wherein R^2 represents an amino group protected with a protecting group, the method comprising a step of converting a compound represented by formula (F):

[0080]

[Chem. 35]



(F)

[0081]

wherein R^1 represents an amino group protected with a protecting group and R^2 represents the same meaning as above, into the compound represented by formula (G) in a solvent comprising hydrochloric acid/ethanol.

[91] The production method according to [90], wherein R^1 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[92] The production method according to [90], wherein R^1 is an amino group protected with an acetyl group or a trifluoroacetyl group.

[93] The production method according to [90], wherein R^1 is an amino group protected with an acetyl group.

[94] The production method according to any one of [90] to [93], wherein R^2 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

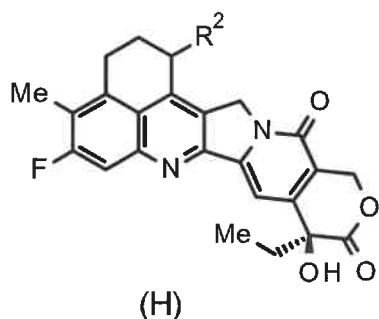
[95] The production method according to any one of [90] to [93], wherein R^2 is an amino group protected with an acetyl group or a trifluoroacetyl group.

[96] The production method according to any one of [90] to [93], wherein R^2 is an amino group protected with an acetyl group.

[97] A method for producing a compound represented by formula (H):

[0082]

[Chem. 39]

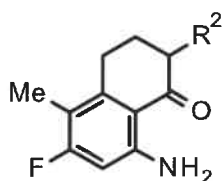


[0083]

wherein R^2 represents an amino group protected with a protecting group, the method comprising a step of condensing a compound represented by formula (G):

[0084]

[Chem. 37]



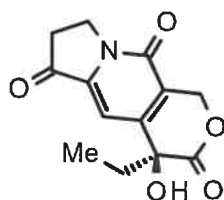
(G)

[0085]

wherein R^2 represents the same meaning as above, with a compound represented by formula (1):

[0086]

[Chem. 38]



(1)

[0087]

in a solvent comprising o-cresol to convert the compound represented by formula (G) into the compound represented by formula (H).

[98] The production method according to [97], wherein R^2 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a

trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

[99] The production method according to [97], wherein R² is an amino group protected with an acetyl group or a trifluoroacetyl group.

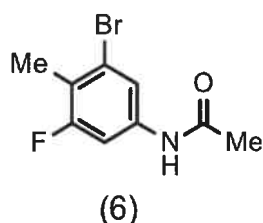
[100] The production method according to [97], wherein R² is an amino group protected with an acetyl group.

[101] The production method according to any one of [1] to [100], wherein no chromatography is used.

[102] A compound represented by formula (6).

[0088]

[Chem. 40]

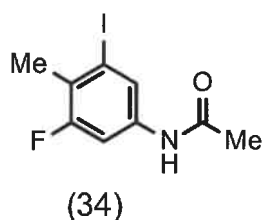


[0089]

[103] A compound represented by formula (34).

[0090]

[Chem. 41]

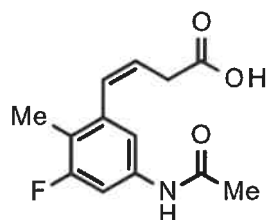


[0091]

[104] A compound represented by formula (7).

[0092]

[Chem. 42]



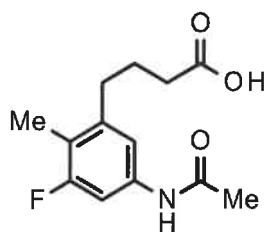
(7)

[0093]

[105] A compound represented by formula (8).

[0094]

[Chem. 43]



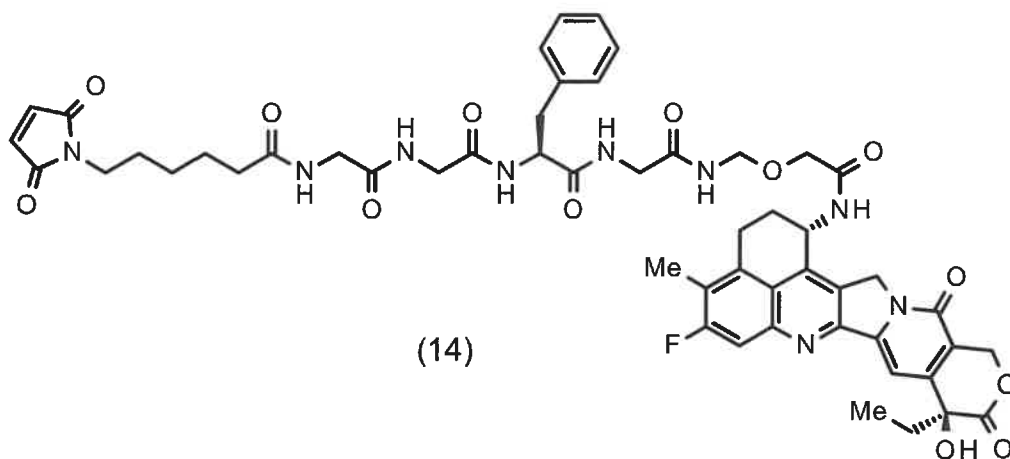
(8)

[0095]

[106] A method for producing a compound represented by formula (14):

[0096]

[Chem. 46]

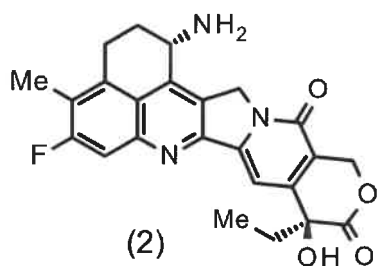


[0097]

wherein a compound represented by formula (2):

[0098]

[Chem. 44]



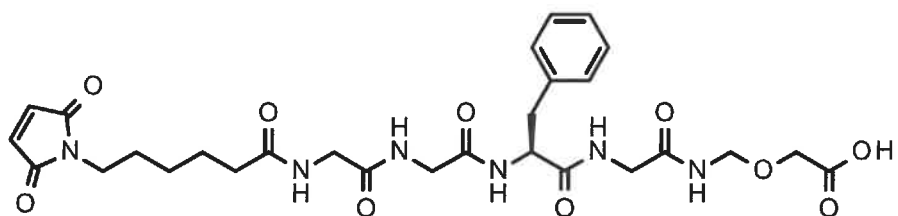
[0099]

produced by the method according to any one of [34] to [65] is used as a starting material, the method comprising the steps of:

condensing the compound represented by formula (2) with a compound represented by formula (13):

[0100]

[Chem. 45]



(13)

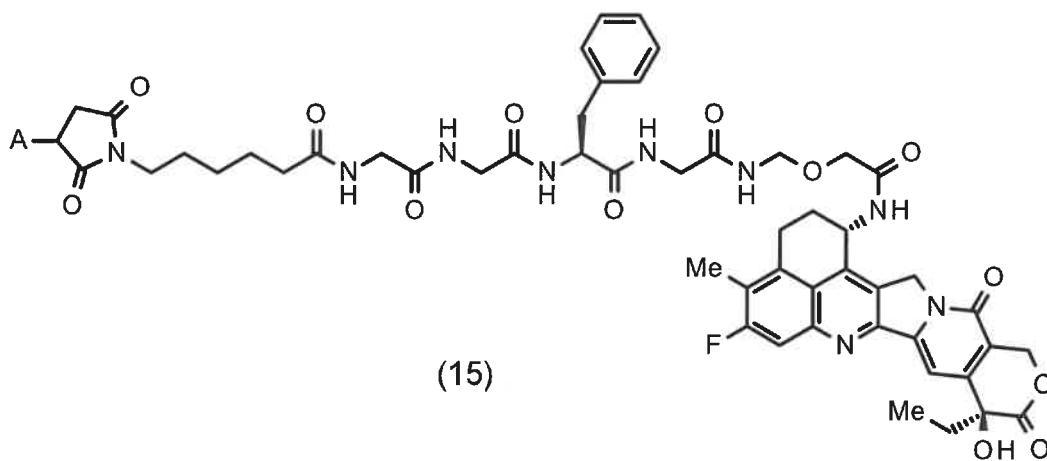
[0101]

to convert the compound represented by formula (2) into the compound represented by formula (14).

[107] A method for producing an antibody-drug conjugate, in which a drug-linker represented by formula (15):

[0102]

[Chem. 48]



(15)

[0103]

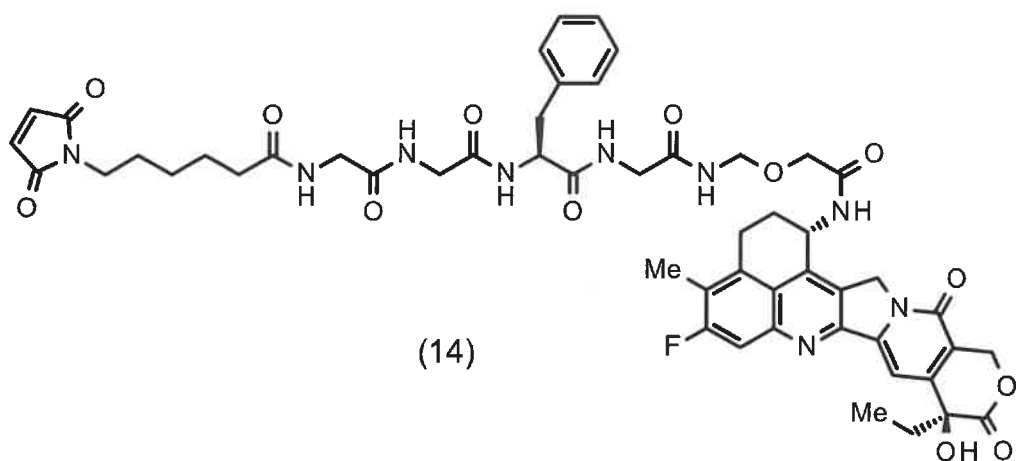
wherein A represents the connecting position to an antibody;

is conjugated to the antibody via a thioether bond,

wherein a compound represented by formula (14):

[0104]

[Chem. 47]



[0105]

produced by the method according to [106] is used as a raw material,

the method comprising the steps of:

- (i) reducing an antibody; and then
- (ii) reacting the compound represented by formula (14) produced by the method with the reduced antibody.

[108] The production method according to [107], wherein the antibody is an anti-HER2 antibody, an anti-HER3 antibody, an anti-TROP2 antibody, an anti-B7-H3 antibody, or an anti-GPR20 antibody.

[109] The production method according to [108], wherein the antibody is an anti-HER2 antibody.

[110] The production method according to [109], wherein the anti-HER2 antibody is an antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 1 to 449 of SEQ ID NO: 1 and a light chain consisting of an amino acid sequence consisting of amino acid residues 1 to 214 of SEQ ID NO: 2; or an

antibody comprising a heavy chain consisting of the amino acid sequence represented by SEQ ID NO: 1 and a light chain consisting of the amino acid sequence represented by SEQ ID NO: 2.

[111] The production method according to [109] or [110], wherein the average number of units of the drug-linker conjugated per antibody molecule in the antibody-drug conjugate is in the range of from 7 to 8.

[112] The production method according to [108], wherein the antibody is an anti-HER3 antibody.

[113] The production method according to [112], wherein the anti-HER3 antibody is an antibody comprising a heavy chain consisting of the amino acid sequence represented by SEQ ID NO: 3 and a light chain consisting of the amino acid sequence represented by SEQ ID NO: 4, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[114] The production method according to [112] or [113], wherein the average number of units of the drug-linker conjugated per antibody molecule in the antibody-drug conjugate is in the range of from 7 to 8.

[115] The production method according to [108], wherein the antibody is an anti-TROP2 antibody.

[116] The production method according to [115], wherein the anti-TROP2 antibody is an antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 20 to 470 of SEQ ID NO: 5 and a light

chain consisting of an amino acid sequence consisting of amino acid residues 21 to 234 of SEQ ID NO: 6, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[117] The production method according to [115] or [116], wherein the average number of units of the drug-linker conjugated per antibody molecule in the antibody-drug conjugate is in the range of from 3 to 5.

[118] The production method according to [108], wherein the antibody is an anti-B7-H3 antibody.

[119] The production method according to [118], wherein the anti-B7-H3 antibody is an antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 20 to 471 of SEQ ID NO: 7 and a light chain consisting of an amino acid sequence consisting of amino acid residues 21 to 233 of SEQ ID NO: 8, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[120] The production method according to [118] or [119], wherein the average number of units of the drug-linker conjugated per antibody molecule in the antibody-drug conjugate is in the range of from 3 to 5.

[121] The production method according to [108], wherein the antibody is an anti-GPR20 antibody.

[122] The production method according to [121], wherein the anti-GPR20 antibody is an antibody comprising a heavy chain consisting of an amino acid sequence consisting of

amino acid residues 20 to 472 of SEQ ID NO: 9 and a light chain consisting of an amino acid sequence consisting of amino acid residues 21 to 234 of SEQ ID NO: 10, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[123] The production method according to [121] or [122], wherein the average number of units of the drug-linker conjugated per antibody molecule in the antibody-drug conjugate is in the range of from 7 to 8.

Advantageous Effects of Invention

[0106]

The present invention can provide a novel, industrially superior method for producing exatecan wherein the number of steps is small. Moreover, the present invention can provide a novel method for producing an antibody-drug conjugate wherein the aforementioned method is used.

Brief Description of Drawings

[0107]

[Figure 1] Figure 1 shows an amino acid sequence of a heavy chain of an anti-HER2 antibody (SEQ ID NO: 1).

[Figure 2] Figure 2 shows an amino acid sequence of a light chain of an anti-HER2 antibody (SEQ ID NO: 2).

[Figure 3] Figure 3 shows an amino acid sequence of a heavy chain of an anti-HER3 antibody (SEQ ID NO: 3).

[Figure 4] Figure 4 shows an amino acid sequence of a light chain of an anti-HER3 antibody (SEQ ID NO: 4).

[Figure 5] Figure 5 shows an amino acid sequence of a heavy chain of an anti-TROP2 antibody (SEQ ID NO: 5).

[Figure 6] Figure 6 shows an amino acid sequence of a light chain of an anti-TROP2 antibody (SEQ ID NO: 6).

[Figure 7] Figure 7 shows an amino acid sequence of a heavy chain of an anti-B7-H3 antibody (SEQ ID NO: 7).

[Figure 8] Figure 8 shows an amino acid sequence of a light chain of an anti-B7-H3 antibody (SEQ ID NO: 8).

[Figure 9] Figure 9 shows an amino acid sequence of a heavy chain of an anti-GPR20 antibody (SEQ ID NO: 9).

[Figure 10] Figure 10 shows an amino acid sequence of a light chain of an anti-GPR20 antibody (SEQ ID NO: 10).

Description of Embodiments

[0108]

Hereinafter, preferred modes for carrying out the present invention are described. The embodiments described below are given merely for illustrating one example of a typical embodiment of the present invention and are not intended to limit the scope of the present invention.

[0109]

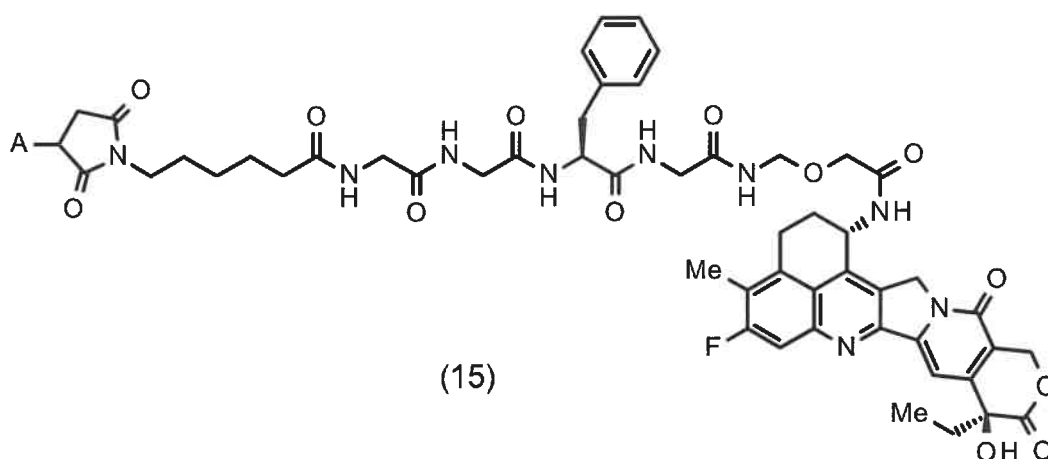
[Antibody-drug conjugate]

[0110]

The antibody-drug conjugate produced by the present invention is preferably an antibody-drug conjugate in which a drug-linker represented by formula (15):

[0111]

[Chem. 49]



[0112]

wherein A represents the connecting position to an antibody,
is conjugated to the antibody via a thioether bond.

[0113]

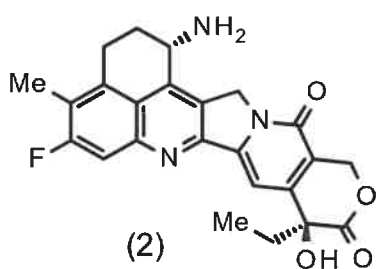
In the present invention, the partial structure consisting of a linker and a drug in the antibody-drug conjugate is referred to as a "drug-linker". The drug-linker is connected to a thiol group (in other words, the sulfur atom of a cysteine residue) formed at an interchain disulfide bond site (two sites between heavy chains, and two sites between a heavy chain and a light chain) in the antibody.

[0114]

The drug-linker of the present invention includes exatecan, which is a topoisomerase I inhibitor, as a component. Exatecan is the compound represented by formula (2):

[0115]

[Chem. 50]



[0116]

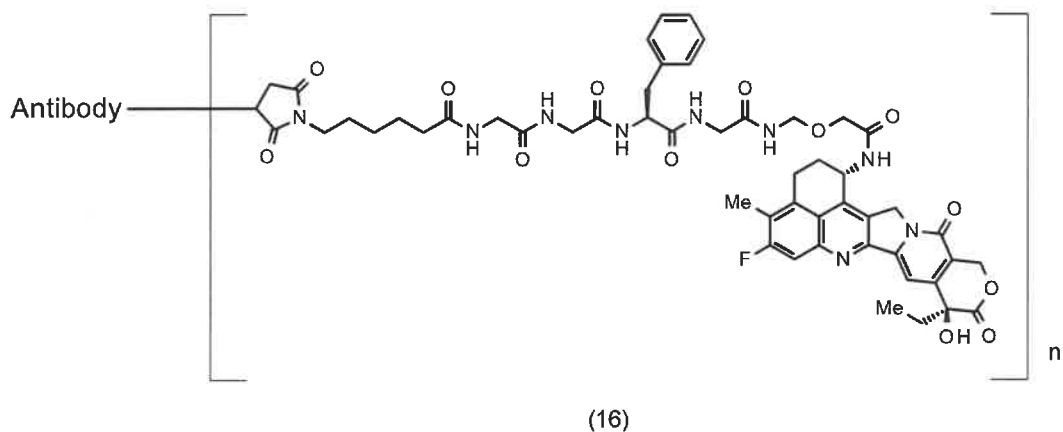
and is a camptothecin derivative having an antitumor effect.

[0117]

The antibody-drug conjugate used in the present invention can also be represented by formula (16):

[0118]

[Chem. 51]



[0119]

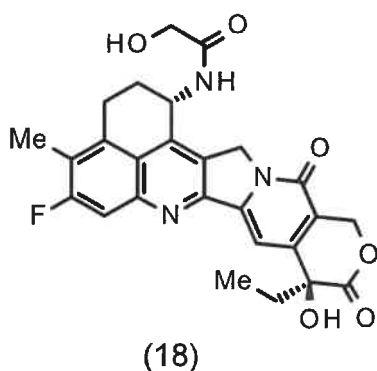
[0120]

wherein the drug-linker is conjugated to an antibody via a thioether bond. The meaning of n is the same as that of what is called the average number of conjugated drug molecules (DAR; Drug-to-Antibody Ratio), and indicates the average number of units of the drug-linker conjugated per antibody molecule.

After migrating into cancer cells, the antibody-drug conjugate used in the present invention releases the compound represented by formula (18):

[0121]

[Chem. 52]



[0122]

and thereby exerts an anti-tumor effect.

[0123]

The compound represented by formula (18) is inferred to be the original source of the antitumor activity of the antibody-drug conjugate produced by the present invention, and has been confirmed to have a topoisomerase I inhibitory effect (Ogitani Y. et al., Clinical Cancer

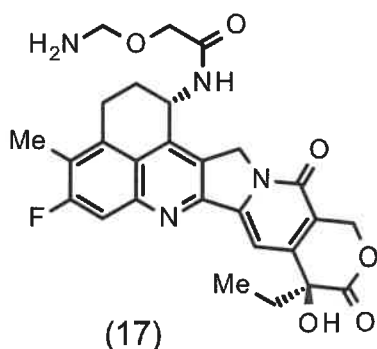
Research, 2016, Oct 15; 22(20):5097-5108, Epub 2016 Mar 29).

[0124]

The compound represented by formula (18) is inferred to be formed by decomposition of an aminor structure of the compound represented by formula (17):

[0125]

[Chem. 53]



[0126]

which is inferred to be formed by cleavage at the linker part of the antibody-drug conjugate produced by the present invention.

The antibody-drug conjugate produced by the present invention is known to have a bystander effect (Ogitani Y. et al., Cancer Science (2016) 107, 1039-1046).

The bystander effect is exerted through a process in which the antibody-drug conjugate produced by the present invention is internalized in cancer cells expressing a target and the compound represented by formula (18) released then exerts an antitumor effect also on cancer

cells which are present therearound and not expressing the target.

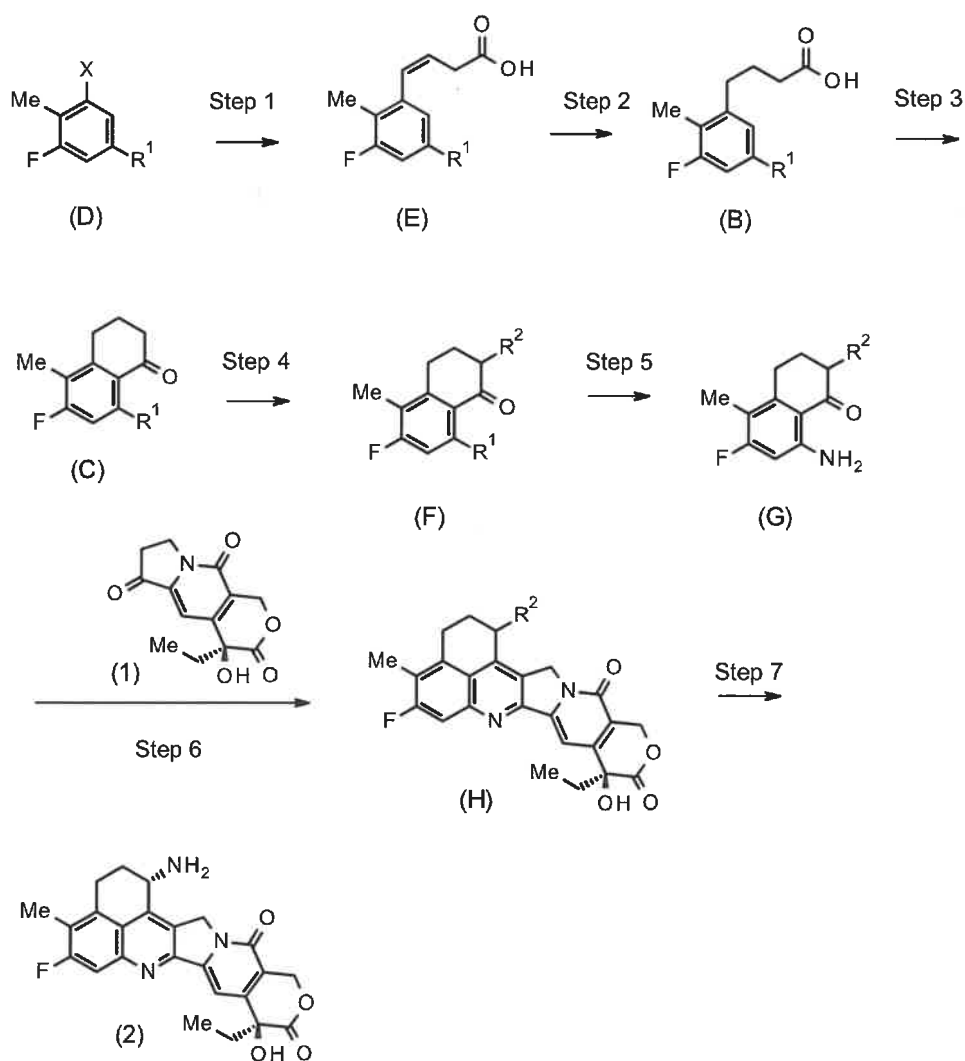
[0127]

[Production of exatecan]

The production of exatecan according to the present invention can be performed by the following method:

[0128]

[Chem. 54]



[0129]

In the scheme, X represents a leaving group, preferably represents a bromo group, an iodo group, a trifluoromethanesulfonyloxy group, or an arylsulfonyloxy group, more preferably represents a bromo group or an iodo group, and even more preferably a bromo group; R¹ represents an amino group protected with a protecting group, preferably represents an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group, more preferably represents an amino group protected with an acetyl group or a trifluoroacetyl group, and even more preferably represents an amino group protected with an acetyl group; and R² represents a protected amino group, preferably represents an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group, more preferably represents an amino group protected with an acetyl group or a trifluoroacetyl group, and even more preferably represents an amino group protected with an acetyl group.

[0130]

Step 1:

This step is a step of coupling a compound represented by formula (D) with 3-butenic acid to convert the compound into a compound represented by formula (E). The compound represented by formula (D) can

be produced with reference to a known method. The amount of 3-butenic acid used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 1.5 equivalents based on the compound represented by formula (D).

[0131]

The coupling reaction can be performed in the presence of a transition metal catalyst, preferably in the presence of a palladium catalyst. The palladium catalyst used in this step is not particularly limited as long as the reaction proceeds, and, for example, divalent palladium salts such as palladium(II) acetate, palladium(II) trifluoroacetate, palladium(II) chloride, palladium(II) bromide, palladium(II) iodide, and bis(triphenylphosphine)palladium(II) chloride, complexes thereof, zero-valent palladium metals such as palladium black, palladium carbon, tetrakis(triphenylphosphine)palladium(0), bis(dibenzylideneacetone)palladium(0), and complexes thereof can be used, and palladium(II) acetate can preferably be used. The amount of the palladium catalyst used in this step is not limited as long as the reaction proceeds, and is preferably 0.003 to 0.03 equivalents based on the compound represented by formula (D).

[0132]

Moreover, in this step, in addition to the above palladium catalyst, a ligand for forming a palladium

complex in the reaction system can preferably be used. Examples of the ligand that can be used in this step include triphenyl phosphine, tri(o-tolyl)phosphine, tri(3-methoxyphenyl)phosphine, tri(4-chlorophenyl)phosphine, tri(2-furyl)phosphine, tri(2-thienyl)phosphine, 1,2-bis(diphenylphosphino)ethane, and Buchwald ligands (such as 2-dicyclohexylphosphino-2',6'-dimethoxybiphenyl (SPhos) and 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl (XPhos)), and tri(o-tolyl)phosphine can preferably be used. The amount of the ligand used in this step is not limited as long as the reaction proceeds, and is preferably 0.006 to 0.06 equivalents based on the compound represented by formula (D).

[0133]

This step can be suitably performed in the presence of a base. The base used in the present step is not particularly limited as long as the reaction proceeds, and examples include organic bases such as triethylamine, tributylamine, diisopropylethylamine, N-methylmorpholine, N-methylpyrrolidine, N-methylpiperidine, pyridine, 2-methylpyridine, 2,6-dimethylpyridine, 4-dimethylaminopyridine, 1,4-diazabicyclo[2.2.2]octane, 1,8-diazabicyclo[5.4.0]undec-7-ene, and 1,5-diazabicyclo[4.3.0]undec-7-ene, and inorganic bases such as potassium carbonate, potassium hydroxide, potassium hydrogen carbonate, sodium carbonate, sodium hydroxide,

sodium hydrogen carbonate, sodium acetate, potassium acetate, sodium methoxide, sodium ethoxide, and potassium tert-butoxide; preferably include triethylamine, tributylamine, diisopropylethylamine, potassium carbonate, potassium hydroxide, potassium hydrogen carbonate, sodium carbonate, sodium hydroxide, sodium hydrogen carbonate, sodium acetate, and potassium acetate; and more preferably include diisopropylethylamine. The amount of the base used in this step is not limited as long as the reaction proceeds, and is preferably 2 to 3 equivalents based on the compound represented by formula (D).

[0134]

The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and, for example, acetonitrile, dichloromethane, chloroform, methanol, ethanol, diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, acetone, 2-butanone, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof can be used, and tetrahydrofuran is preferred.

[0135]

The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 45 to 85°C, and more preferably a temperature at which

tetrahydrofuran is thermally refluxed. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 2.5 to 10 hours.

[0136]

The compound represented by formula (E) can preferably be purified by performing the steps of dissolving the compound represented by formula (E) in a basic aqueous solution to wash the compound represented by formula (E) with a first organic solvent and separating the solvents, and then adding an acid to the basic aqueous solution to extract the compound represented by formula (E) with a second organic solvent and separating the solvents. The first organic solvent is preferably 2-methyltetrahydrofuran. The second organic solvent is preferably 2-methyltetrahydrofuran. The basic aqueous solution is preferably an aqueous sodium hydroxide solution.

[0137]

E and Z forms of the compound represented by formula (E) exist as geometric isomers, and both are encompassed within the compound represented by formula (E) and are thus encompassed within the scope of the present invention. The compound represented by formula (E) of the present invention may be a mixture of the E and Z forms, and the mixture can be directly used in the next step.

[0138]

In this step, a 3-butenic acid ester can also be used in place of 3-butenic acid. In such a case, the product obtained by coupling the compound represented by formula (D) with a 3-butenic acid ester can be hydrolyzed to convert the compound into the compound represented by formula (E).

[0139]

Step 2:

This step is a step of reducing the compound represented by formula (E) to convert the compound into a compound represented by formula (B).

[0140]

The reduction in this step is not limited as long as the reaction proceeds, and can preferably be performed under a hydrogen atmosphere (preferably in a hydrogen stream of 0.05 to 0.6 MPa) using a palladium catalyst, a platinum catalyst, a nickel catalyst, a ruthenium catalyst, or a rhodium catalyst, more preferably it can be performed using a palladium catalyst, even more preferably it can be performed using palladium carbon, and still more preferably it can be performed using 5% palladium carbon. The amount of 5% palladium carbon used in this step is not limited as long as the reaction proceeds, and is preferably 5 to 80% by weight based on the compound represented by formula (D) used in step 1.

[0141]

The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include acetonitrile, dichloromethane, chloroform, methanol, ethanol, diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, acetone, 2-butanone, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof, and preferably 2-methyltetrahydrofuran.

[0142]

The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 20 to 60°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 0.5 to 2 hours.

[0143]

Step 3:

This step is a step of subjecting the compound represented by formula (B) to intramolecular cyclization to convert the compound into a compound represented by formula (C). Intramolecular cyclization can preferably be performed by an intramolecular Friedel-Crafts acylation reaction. Concerning the intramolecular Friedel-Crafts acylation reaction in this step, the method is not limited as long as the reaction proceeds,

and preferred examples include a method involving trifluoroacetic anhydride and a method involving thionyl chloride, sulfuryl chloride, oxalyl chloride, phosphorus oxychloride, phosphorus trichloride, or phosphorus pentachloride, more preferably a method involving trifluoroacetic anhydride or thionyl chloride, and even more preferably a method involving trifluoroacetic anhydride. The amount of trifluoroacetic anhydride used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 3 equivalents based on the compound represented by formula (B). The amount of thionyl chloride used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 3 equivalents based on the compound represented by formula (B).

[0144]

In the case of a method involving trifluoroacetic anhydride, this step is preferably performed in the presence of acid, and is more preferably performed in the presence of trifluoroacetic acid. In the case of a method involving thionyl chloride, sulfuryl chloride, oxalyl chloride, phosphorus oxychloride, phosphorus trichloride, or phosphorus pentachloride, this step is preferably performed in the presence of aluminium chloride. The amount of aluminium chloride used in this step is not limited as long as the reaction proceeds, and

is preferably 1 to 5 equivalents based on the compound represented by formula (B).

[0145]

The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include dichloromethane, chloroform, diethyl ether, 1,2-dimethoxyethane, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, and chlorobenzene, and mixed solvents thereof, and preferably methylene chloride. In the case of a method involving trifluoroacetic acid, trifluoroacetic acid can preferably be included as a solvent.

[0146]

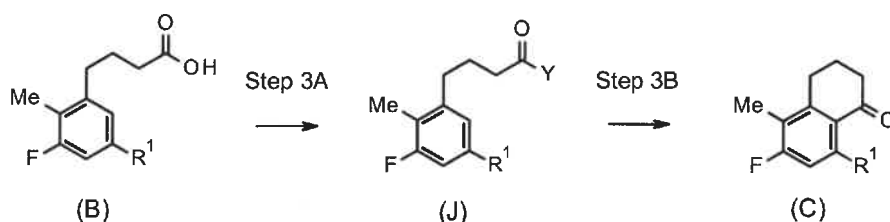
The reaction temperature of this step is not limited as long as the reaction proceeds, and in the case of a method involving trifluoroacetic anhydride, the reaction temperature is preferably -10°C to 20°C , and in the case of a method involving thionyl chloride, the reaction temperature is preferably 10°C to 40°C . The reaction time of this step is not limited as long as the reaction proceeds, and in the case of a method involving trifluoroacetic anhydride, the reaction time is preferably 2 hours to 8 hours, and in the case of a method involving thionyl chloride, the reaction time is preferably 1 hour to 4 hours.

[0147]

This step can also be divided into the following two sub-steps:

[0148]

[Chem. 55]



[0149]

In the scheme, Y represents a leaving group, preferably represents a chloro group, a bromo group, an iodo group, a fluoro group, or a trifluoroacetoxy group, and more preferably represents a chloro group or a trifluoroacetoxy group; and R¹ represents an amino group protected with a protecting group, preferably represents an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group, more preferably represents an amino group protected with an acetyl group or a trifluoroacetyl group, and even more preferably represents an amino group protected with an acetyl group.

[0150]

Step 3A is a step of converting the compound represented by formula (B) into a compound represented by formula (J).

[0151]

When Y is a chloro group, this step can preferably be performed by a method involving thionyl chloride, sulfuryl chloride, oxalyl chloride, phosphorus oxychloride, phosphorus trichloride, or phosphorus pentachloride, and this step can be more preferably performed by a method involving thionyl chloride. The amount of thionyl chloride used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 3 equivalents based on the compound represented by formula (B). When Y is a trifluoroacetoxy group, this step can preferably be performed by a method involving trifluoroacetic anhydride. The amount of trifluoroacetic anhydride used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 3 equivalents based on the compound represented by formula (B). The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include dichloromethane, chloroform, diethyl ether, 1,2-dimethoxyethane, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, trifluoroacetic acid, and mixed solvents thereof, preferably methylene chloride in the case of a method involving thionyl chloride, and preferably trifluoroacetic acid in the case of a method involving trifluoroacetic anhydride.

[0152]

Step 3B is a step of converting the compound represented by formula (J) into a compound represented by formula (C). In the case of a method involving thionyl chloride, this step can preferably be performed in the presence of aluminium chloride. The amount of aluminium chloride used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 5 equivalents based on the compound represented by formula (B). In the case of a method involving trifluoroacetic anhydride, this step can preferably be performed in the presence of an acid, and this step can more preferably be performed in the presence of trifluoroacetic acid.

[0153]

The reaction temperature of step 3A and step 3B is not limited as long as the reactions proceed, and in the case of a method involving thionyl chloride, the reaction temperature is preferably 10°C to 40°C, and in the case of a method involving trifluoroacetic anhydride, the reaction temperature is preferably -10°C to 20°C. The total reaction time of step 3A and step 3B is not limited as long as the reaction proceeds, and in the case of a method involving thionyl chloride, the total reaction time is preferably 1 hour to 4 hours, and in the case of a method involving trifluoroacetic anhydride, the total reaction time is preferably 2 hours to 8 hours.

[0154]

Step 4:

Step 4 is a step of converting the compound represented by formula (C) into a compound represented by formula (F). This step can preferably be performed by the sub-steps of (i) nitrosating (or oximating) the α -position of the carbonyl group, (ii) introducing a protecting group to the nitrogen atom derived from the nitroso group (or the oxime group), and (iii) reducing. Sub-steps (ii) and (iii) may be performed in a reversed order, or may be simultaneously performed.

[0155]

The nitrosating agent (or the oximating agent) used in sub-step (i) is not particularly limited as long as the α -position of the carbonyl group of the compound represented by formula (C) can be nitrosated (or oximated), and nitrous acid esters can preferably be used, amyl nitrite, n-butyl nitrite, and tert-butyl nitrite can more preferably be used, and amyl nitrite can even more preferably be used. The amount of amyl nitrite used in sub-step (i) is not limited as long as the reaction proceeds, and is preferably 1 to 1.6 equivalents based on the compound represented by formula (C).

[0156]

A base is preferably used in sub-step (i). The base used in sub-step (i) is not particularly limited as long as it is applicable to the nitrosation (or the oximation) of the α -position of the carbonyl group of the compound represented by formula (C), and potassium tert-butoxide

can preferably be used. The amount of potassium tert-butoxide used in sub-step (i) is not limited as long as the reaction proceeds, and is preferably 1 to 1.5 equivalents based on the compound represented by formula (C).

[0157]

The solvent used in sub-step (i) is not particularly limited as long as it does not inhibit the reaction, and examples include diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, dimethyl sulfoxide, and mixed solvents thereof, and preferably tetrahydrofuran.

[0158]

The reaction temperature of sub-step (i) is not limited as long as the reaction proceeds, and is preferably -10 to 20°C. The reaction time of this sub-step is not limited as long as the reaction proceeds, and is preferably 1.5 to 30 hours.

The reaction conditions of sub-step (ii) can be suitably set according to the type of protecting group for amino group R². When R² is an amino group protected with an acetyl group, acetic anhydride in acetic acid can preferably be used in sub-step (ii).

[0159]

Sub-step (iii) can be performed under a hydrogen atmosphere (preferably in a hydrogen stream at 0.15 to

1.2 MPa) using, for example, a platinum carbon catalyst or zinc powder, can preferably be performed using a platinum carbon catalyst, and can more preferably be performed using a 2% or 5% platinum carbon catalyst. The amount of the 2% or 5% platinum carbon catalyst is not limited as long as the reaction proceeds, and is preferably 5 to 60% by weight based on the compound represented by formula (C). In sub-step (iii), a solvent as used in sub-step (ii) can be used.

The reaction temperature of sub-steps (ii) and (iii) is not limited as long as the reactions proceed, and is preferably 0 to 40°C. The total reaction time of sub-steps (ii) and (iii) is not limited as long as the reactions proceed, and is preferably 2 to 8 hours.

[0160]

Step 5:

This step is the step of selectively deprotecting the protecting group for the aromatic amino group of the compound represented by formula (F) to convert the compound into a compound represented by formula (G). The reaction conditions of this step can suitably be set according to the type of the protecting group for amino groups R^1 and R^2 . When R^1 and R^2 are amino groups protected with an acetyl group, this step can preferably be performed using hydrochloric acid, and can more preferably be performed using 2N hydrochloric acid/ethanol.

The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 40 to 60°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 2 to 14 hours.

[0161]

Step 6:

This step is a step of condensing the compound represented by formula (G) with a compound represented by formula (1) to convert the compound into a compound represented by formula (H). The compound represented by formula (1) can be produced with reference to descriptions in US Patent No. 4778891 or the like, or a commercially available compound can be used. The amount of the compound represented by formula (1) used in this step is not limited as long as the reaction proceeds, and is preferably 0.8 to 1.2 equivalents based on the compound represented by formula (G).

[0162]

This step is performed in the presence of an acid catalyst. A preferred example of the acid catalyst used in this step can be pyridinium p-toluenesulfonate. The amount of the acid catalyst used in this step is not limited as long as the reaction proceeds, and is preferably 0.03 to 0.3 equivalents based on the compound represented by formula (G).

[0163]

This step is preferably performed in a solvent containing cresol or phenol, and more preferably performed in toluene containing o-cresol. Due to the presence of o-cresol or phenol, the compound represented by formula (H) is precipitated in an improved manner, and effects such as an improved yield and a shortened reaction time can be observed.

[0164]

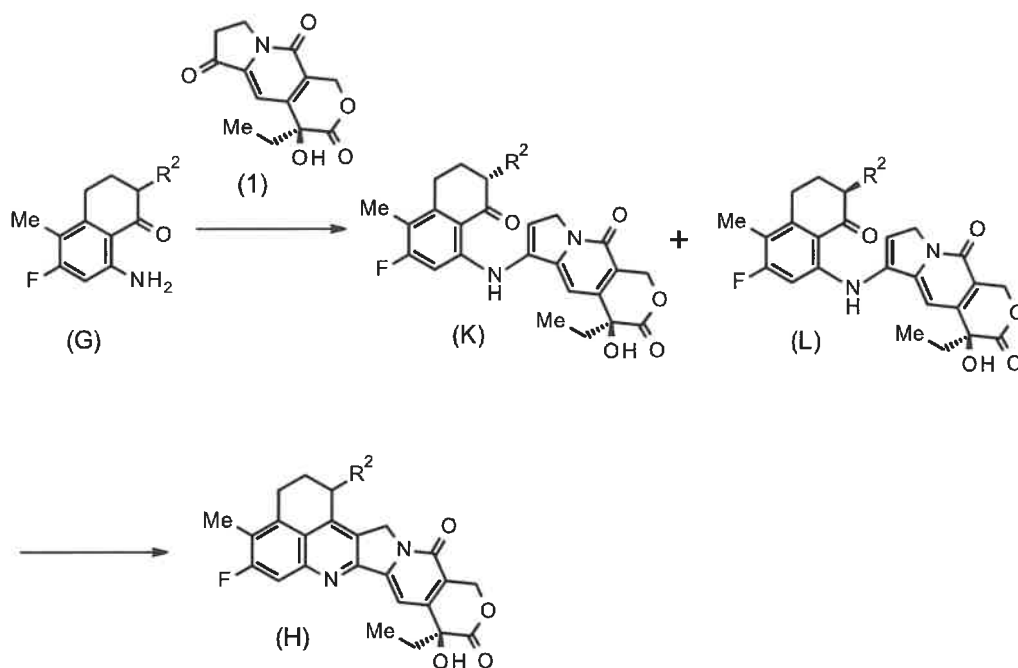
The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 90 to 130°C, and more preferably a temperature at which toluene is thermally refluxed. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 16 to 64 hours.

[0165]

This step is considered to proceed via a compound represented by formula (K) and a compound represented by formula (L) as reaction intermediates.

[0166]

[Chem. 56]



[0167]

Step 7:

This step is a step of converting a compound represented by formula (H) into a compound represented by formula (2). The compound represented by formula (2) may be a salt or even a hydrate, and both are encompassed within the scope of a "compound represented by formula (2)" in the present invention.

This step can preferably be performed in the presence of acid, and more preferably in the presence of methanesulfonic acid and water.

[0168]

The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, preferably solvents containing 2-methoxyethanol and

ethylcyclohexane can be used, and, moreover, in the case of including the above acid as a solvent, a mixed solvent of methanesulfonic acid, water, 2-methoxyethanol, and ethylcyclohexane can more preferably be used.

[0169]

This step is not limited as long as the reaction proceeds, and can preferably be performed at 80 to 160°C and can more preferably be performed at a temperature at which the mixed solvent of methanesulfonic acid, water, 2-methoxyethanol, and ethylcyclohexane is thermally refluxed. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 4 to 16 hours.

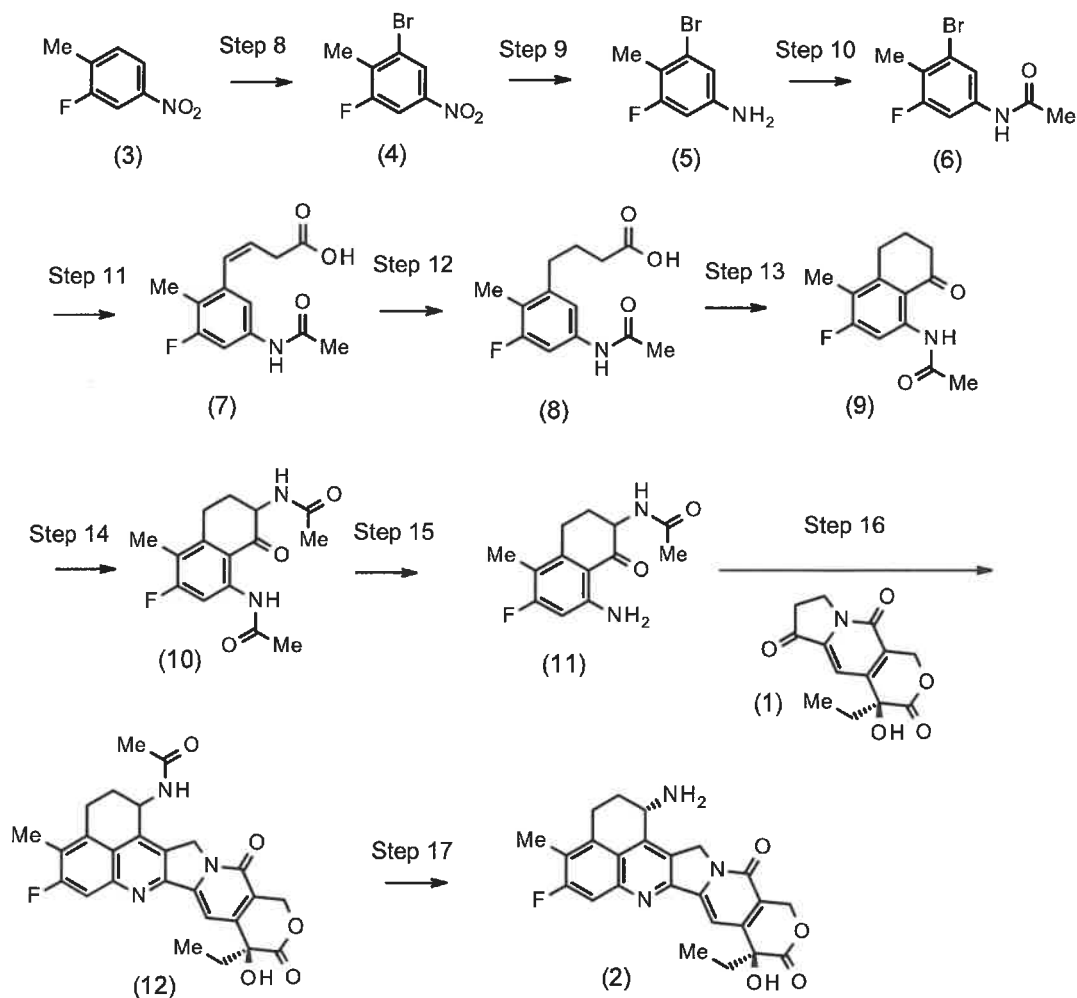
[0170]

The compound represented by formula (2) can preferably be obtained as a methanesulfonic acid salt, can more preferably be obtained as a methanesulfonic acid m-hydrate wherein m is 0 to 3, can even more preferably be obtained as a methanesulfonic acid salt anhydrate, a methanesulfonic acid salt monohydrate, a methanesulfonic acid salt dihydrate, or a methanesulfonic acid salt trihydrate, and can still more preferably be obtained as a methanesulphonic acid dihydrate, any of which can be used in the production method of the present invention. The number of water molecules in the hydrates can be controlled by regulating the humidity available when obtaining and drying crystals.

The compound represented by formula (2) can more preferably be produced according to the following method.

[0171]

[Chem. 57]



[0172]

Step 8:

This step is a step of brominating the compound represented by formula (3) to convert the compound into a compound represented by formula (4). As the compound represented by formula (3), a compound produced by a

known method or a commercially available compound can be used.

[0173]

The brominating agent used in this step is not limited as long as the reaction proceeds, and examples include bromine and N-bromosuccinimide, and preferably N-bromosuccinimide. The amount of N-bromosuccinimide used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 1.5 equivalents based on the compound represented by formula (3). This step can preferably be performed in a mixed solvent of sulfuric acid and a further solvent.

[0174]

The further solvent is not particularly limited as long as it does not inhibit the reaction, and examples include dichloromethane, chloroform, diethyl ether, 1,2-dimethoxyethane, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, and mixed solvents thereof, and preferably heptane.

[0175]

The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 50 to 70°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 0.5 to 2 hours.

[0176]

Step 9:

This step is a step of reducing the nitro group of the compound represented by formula (4) to an amino group to convert the compound into a compound represented by formula (5). The reducing agent used in this step is not limited as long as it does not allow debromination to proceed and is capable of selectively reducing only the nitro group, preferably a platinum carbon catalyst can be used in the presence of hydrogen (preferably in a hydrogen stream of 0.05 to 0.2 MPa), and more preferably a 1% platinum carbon catalyst can be used. The amount of the platinum carbon catalyst used in this step is not limited as long as the reaction proceeds, and is preferably 5 to 40% by weight based on the compound represented by formula (3) used in step 8. The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include methanol, ethanol, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, and water, and mixed solvents thereof, and preferably ethyl acetate. The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 50 to 70°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 2 to 8 hours.

[0177]

Step 10:

This step is a step of acetylating the amino group of the compound represented by formula (5) to convert the compound into a compound represented by formula (6). Examples of the acetylating agent used in this step include acetic anhydride and acetyl chloride, and preferably acetic anhydride. The amount of acetic anhydride used in this step is not limited as long as the reaction proceeds, and is preferably 0.5 to 1 equivalent based on the compound represented by formula (3) used in step 8. A base can preferably be used in this step. The base is not limited as long as the reaction proceeds, and is preferably triethylamine. The amount of the base is not limited as long as the reaction proceeds, and is preferably 0.75 to 1.5 equivalents based on the compound represented by formula (3) used in step 8. The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include acetonitrile, dichloromethane, chloroform, methanol, ethanol, diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, acetone, 2-butanone, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof, and preferably ethyl acetate. The reaction temperature of this step is not limited as long as the reaction proceeds,

and is preferably 10 to 40°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 3 to 12 hours.

[0178]

Step 11:

This step is a step of coupling the compound represented by formula (6) with 3-butenic acid to convert the compound into a compound represented by formula (7). This step can be performed in the same manner as the method described in step 1.

E and Z forms of the compound represented by formula (7) exist as geometric isomers, and both are encompassed within the compound represented by formula (7) and are thus encompassed within the scope of the present invention. The compound represented by formula (7) of the present invention may be a mixture of the E and Z forms, and the mixture can be directly used in the next step.

[0179]

Step 12:

This step is a step of reducing the compound represented by formula (7) to convert the compound into a compound represented by formula (8).

[0180]

The reduction in this step is not limited as long as the reaction proceeds, and can preferably be performed under a hydrogen atmosphere (preferably in a hydrogen

stream of 0.05 to 0.2 MPa) using a palladium catalyst, a platinum catalyst, a nickel catalyst, a ruthenium catalyst, or a rhodium catalyst, more preferably can be performed using a palladium catalyst, and even more preferably can be performed using palladium carbon, and still more preferably 5% palladium carbon can be used. The amount of 5% palladium carbon used in this step is not limited as long as the reaction proceeds, and is preferably 5 to 40% by weight based on the compound represented by formula (7) used in step 11.

[0181]

The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include acetonitrile, dichloromethane, chloroform, methanol, ethanol, diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, acetone, 2-butanone, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof, and preferably 2-methyltetrahydrofuran.

[0182]

The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 20 to 60°C. The reaction time of this step is not limited as

long as the reaction proceeds, and is preferably 0.5 to 2 hours.

[0183]

Step 13:

This step is a step of subjecting the compound represented by formula (8) to intramolecular cyclization to convert the compound into a compound represented by formula (9). This step can be performed in the same manner as the method described in step 3.

[0184]

Step 14:

This step is a step of converting the compound represented by formula (9) into a compound represented by formula (10). This step can be performed in the same manner as the method described in step 4.

[0185]

Step 15:

This step is a step of selectively deprotecting the protecting group for the aromatic amino group of the compound represented by formula (10) to convert the compound into a compound represented by formula (11). This step can be performed in the same manner as the method described in step 5.

[0186]

Step 16:

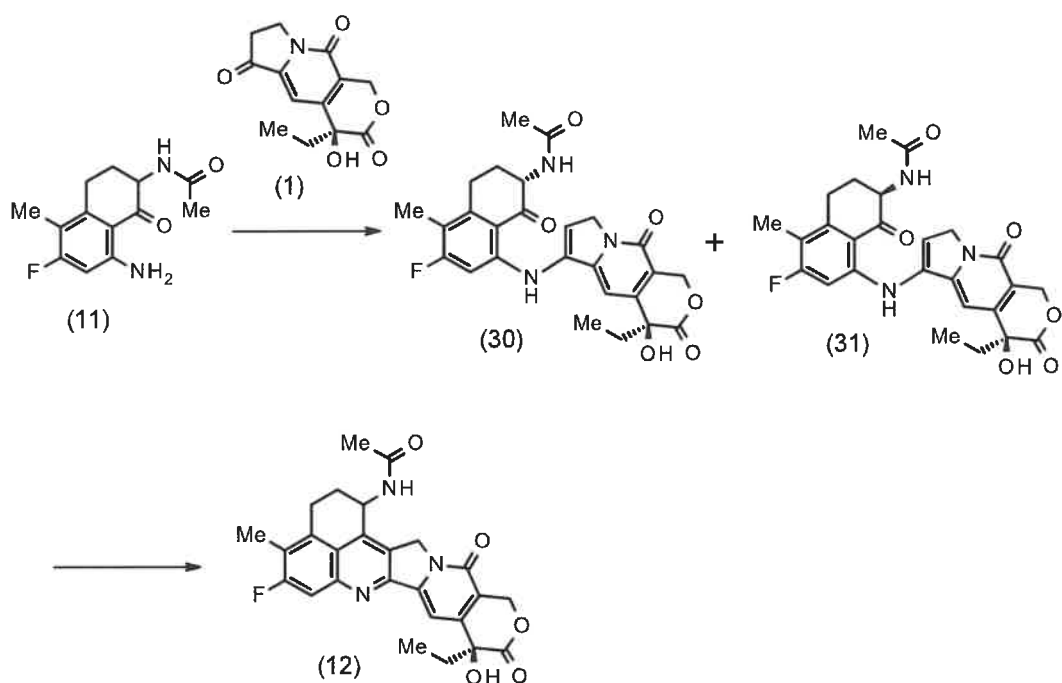
This step is a step of condensing the compound represented by formula (11) with a compound represented

by formula (1) to convert the compound into a compound represented by formula (12). This step can be performed in the same manner as the method described in step 6.

This step is considered to proceed via a compound represented by formula (30) and/or a compound represented by formula (31) as a reaction intermediate.

[0187]

[Chem. 58]



[0188]

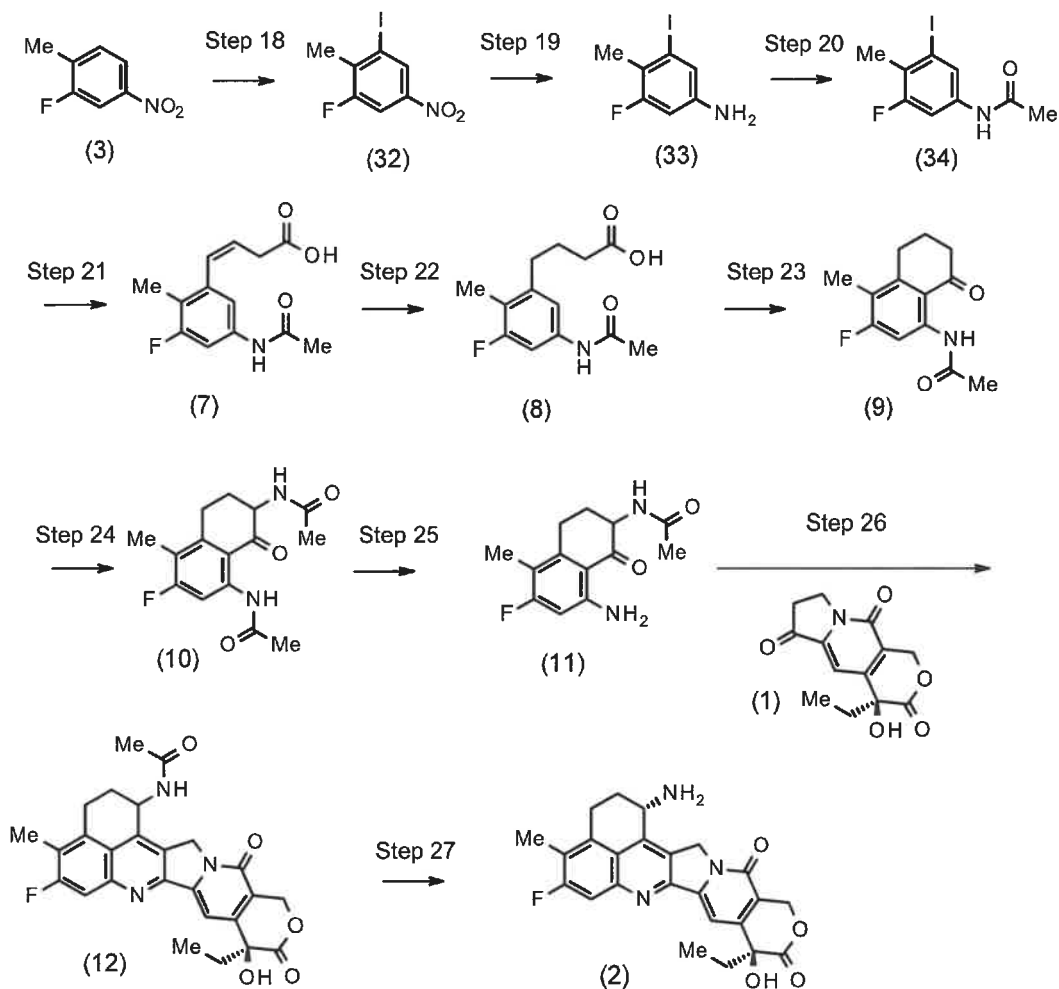
Step 17:

This step is a step of converting the compound represented by formula (12) into the compound represented by formula (2). This step can be performed in the same manner as the method described in step 7.

The compound represented by formula (2) can also be produced according to the following method.

[0189]

[Chem. 59]



[0190]

Step 18:

This step is a step of iodinating the compound represented by formula (3) to convert the compound into a compound represented by formula (32). As the compound represented by formula (3), a compound produced by a

known method or a commercially available compound can be used.

The iodinating agent used in this step is not limited as long as the reaction proceeds, and examples include iodine and N-iodosuccinimide, and preferably N-iodosuccinimide. The amount of N-iodosuccinimide used in this step is not limited as long as the reaction proceeds, and is preferably 1 to 2 equivalents based on the compound represented by formula (3). This step can preferably be performed in a mixed solvent of sulfuric acid and a further solvent.

[0191]

The further solvent is not particularly limited as long as it does not inhibit the reaction, and examples include dichloromethane, chloroform, diethyl ether, 1,2-dimethoxyethane, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, and mixed solvents thereof, and preferably heptane.

The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably -10 to 10°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 1 to 4 hours.

[0192]

Step 19:

This step is a step of reducing the nitro group of the compound represented by formula (32) to an amino

group to convert the compound into a compound represented by formula (33). The reducing agent used in this step is not limited as long as it does not allow deiodination to proceed and is capable of selectively reducing only the nitro group, and preferably a platinum carbon catalyst can be used in the presence of hydrogen (preferably in a hydrogen stream of 0.05 to 0.2 MPa). The amount of the platinum carbon catalyst used in this step is not limited as long as the reaction proceeds, and is preferably 5 to 40% by weight based on the compound represented by formula (3) used in step 18. The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include methanol, ethanol, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, and water, and mixed solvents thereof, and preferably ethyl acetate. The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 50 to 70°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 2 to 8 hours.

[0193]

Step 20:

This step is a step of acetylating the amino group of the compound represented by formula (33) to convert the compound into a compound represented by formula (34). Examples of the acetylating agent used in this step

include acetic anhydride and acetyl chloride, and preferably acetic anhydride. The amount of acetic anhydride used in this step is not limited as long as the reaction proceeds, and is preferably 0.5 to 1 equivalent based on the compound represented by formula (3) used in step 18. A base can preferably be used in this step. The base is not limited as long as the reaction proceeds, and is preferably triethylamine. The amount of the base is not limited as long as the reaction proceeds, and is preferably 0.75 to 1.5 equivalents based on the compound represented by formula (3) used in step 18. The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include acetonitrile, dichloromethane, chloroform, methanol, ethanol, diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, acetone, 2-butanone, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof, and preferably ethyl acetate. The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 10 to 40°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 3 to 12 hours.

[0194]

Step 21:

This step is a step of coupling the compound represented by formula (34) with 3-butenic acid to convert the compound into a compound represented by formula (7). This step can be performed in the same manner as the method described in step 1.

[0195]

Step 22:

This step is a step of reducing the compound represented by formula (7) to convert the compound into a compound represented by formula (8).

[0196]

This step can be performed in the same manner as step 12, but since the catalyst activity may be impaired by the residual iodide ions, this step is preferably performed with a larger amount of a catalyst and a higher hydrogen pressure than those in step 12.

[0197]

The reduction in this step is not limited as long as the reaction proceeds, and can preferably be performed under a hydrogen atmosphere (preferably in a hydrogen stream of 0.15 to 0.6 MPa) using a palladium catalyst, a platinum catalyst, a nickel catalyst, a ruthenium catalyst, or a rhodium catalyst, more preferably can be performed using a palladium catalyst, and even more preferably can be performed using palladium carbon, and still more preferably 5% palladium carbon can be used.

The amount of 5% palladium carbon used in this step is not limited as long as the reaction proceeds, and is preferably 20 to 160% by weight based on the compound represented by formula (34) used in step 21.

[0198]

The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include acetonitrile, dichloromethane, chloroform, methanol, ethanol, diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, acetone, 2-butanone, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof, and preferably 2-methyltetrahydrofuran.

[0199]

The reaction temperature of this step is not limited as long as the reaction proceeds, and is preferably 20 to 60°C. The reaction time of this step is not limited as long as the reaction proceeds, and is preferably 4 to 16 hours.

[0200]

Step 23:

This step is a step of subjecting the compound represented by formula (8) to intramolecular cyclization to convert the compound into a compound represented by

formula (9). This step can be performed in the same manner as the method described in step 3.

[0201]

Step 24:

This step is a step of converting the compound represented by formula (9) into a compound represented by formula (10). This step can be performed in the same manner as the method described in step 4.

[0202]

Step 25:

This step is a step of selectively deprotecting the protecting group for the aromatic amino group of the compound represented by formula (10) to convert the compound into a compound represented by formula (11). This step can be performed in the same manner as the method described in step 5.

[0203]

Step 26:

This step is a step of condensing the compound represented by formula (11) with the compound represented by formula (1) to convert the compound into a compound represented by formula (12). This step can be performed in the same manner as the method described in step 16.

[0204]

Step 27:

This step is a step of converting the compound represented by formula (12) into the compound represented

by formula (2). This step can be performed in the same manner as the method described in step 7.

In the reaction of each of the above steps, after completion of the reaction, the target compound of each step can be isolated from the reaction mixture according to a method well known in the field of organic chemistry. The target compound can be obtained by, for example, (i) filtering off insoluble matter such as a catalyst as necessary, (ii) adding water and a solvent that is immiscible with water (such as methylene chloride, diethyl ether, ethyl acetate, or 2-methyltetrahydrofuran) to the reaction mixture to extract the target compound, (iii) washing the organic layer with water and drying the organic layer using a desiccant such as anhydrous magnesium sulfate, and (iv) distilling off the solvent. While the resulting target compound can be further purified, as necessary, by a method well known in the field of organic chemistry (such as recrystallization, reprecipitation, silica gel column chromatography, or high performance liquid chromatography), preferably the production method of the present invention can be performed without using chromatography.

[0205]

The compound represented by formula (2) obtained by the production method of the present invention can preferably be used to produce an antibody-drug conjugate in which the drug-linker represented by formula (15) is

conjugated to an antibody via a thioether bond, but is not limited thereto, and the compound represented by formula (2) can also be used for the production of an antibody-drug conjugate having another chemical structure and for other applications.

[0206]

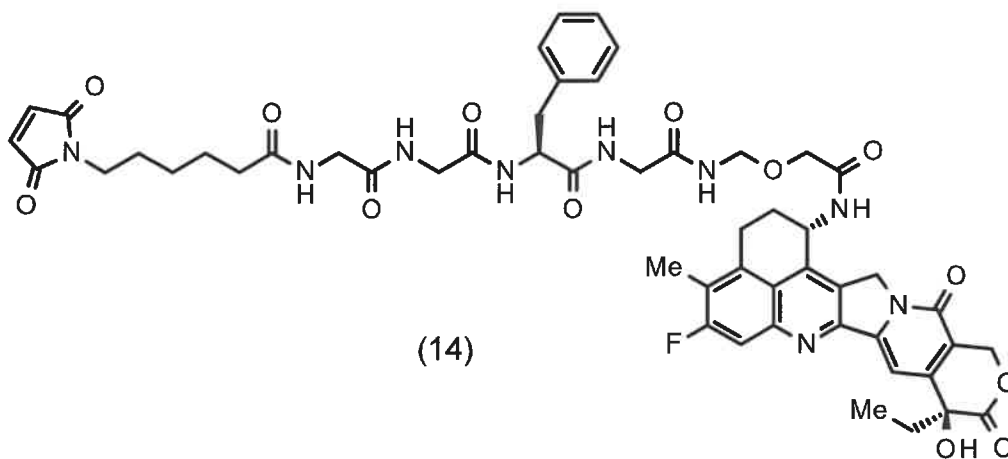
[Production of drug-linker intermediate]

[0207]

The drug-linker intermediate preferably used in the production of the antibody-drug conjugate of the present invention is the compound represented by formula (14).

[0208]

[Chem. 60]

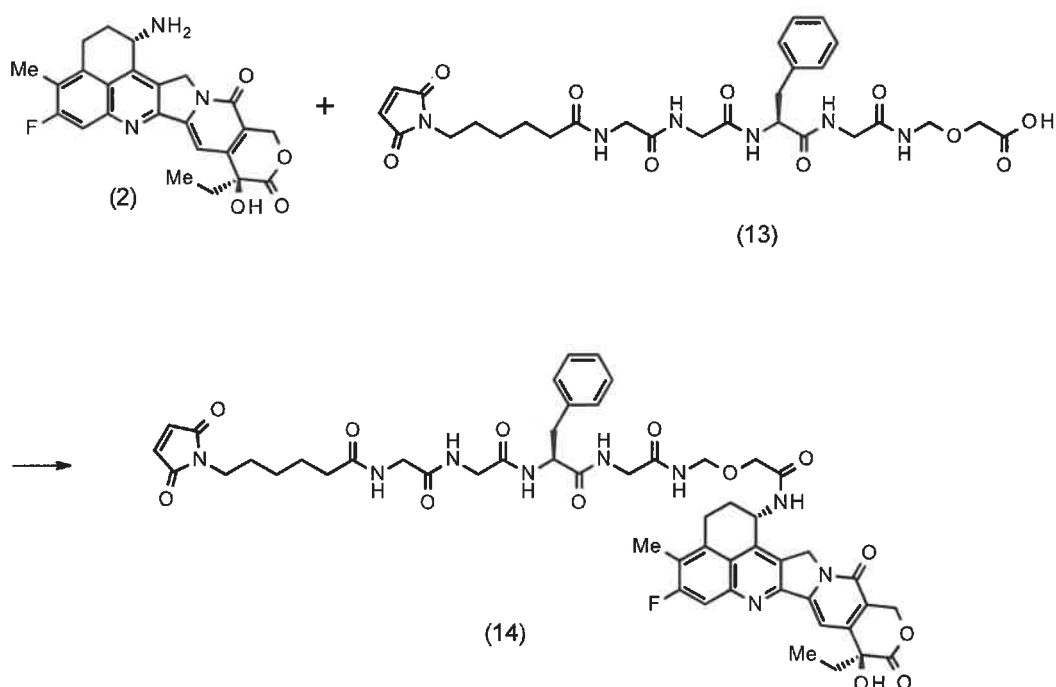


[0209]

The compound represented by formula (14) can be produced as follows.

[0210]

[Chem. 61]



[0211]

As the compound represented by formula (2), a compound produced by the production method of the present invention can be used. The compound represented by formula (13) can be produced with reference to descriptions in International Publication No. WO 2014/057687, International Publication No. WO 2015/098099, International Publication No. WO 2015/115091, and International Publication No. WO 2015/155998.

[0212]

Conversion to the compound represented by formula (14) can be performed by derivatizing the compound represented by formula (13) to an active ester, a mixed acid anhydride, an acid halide, or the like, and reacting

it with the compound represented by formula (2) preferably in the presence of a base.

[0213]

An active ester can be produced by, for example, reacting the compound represented by formula (13) with a condensing agent such as N,N'-dicyclohexylcarbodiimide (DCC) or 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (WSCD·HCl), and an additive such as 1-hydroxybenzotriazole (HOBt), 1-hydroxy-7-azabenzotriazole (HOAt), N-hydroxysuccinimide, or p-nitrophenol. The active ester can also be produced by reacting the compound represented by formula (13) with a condensing agent such as O-(7-azabenzotriazol-1-yl)-N,N,N',N'-tetramethyluronium hexafluorophosphate pentafluorophenyl trifluoroacetate (HATU), O-(benzotriazol-1-yl)-N,N,N',N'-tetramethyluronium hexafluorophosphate (HBTU), diethyl cyanophosphonate, or 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride (DMTMM).

[0214]

A mixed acid anhydride can be produced by, for example, reacting the compound represented by formula (13) with isobutyl chlorocarbonate, in the presence of a base as necessary.

[0215]

A acid halide can be produced by treating the compound represented by formula (13) with an acid halide

such as thionyl chloride or oxalyl chloride, in the presence of a base as necessary.

[0216]

The base used in this step is not particularly limited as long as the reaction proceeds, and examples include organic bases such as triethylamine, tributylamine, diisopropylethylamine, N-methylmorpholine, N-methylpyrrolidine, N-methylpiperidine, pyridine, 2-methylpyridine, 2,6-dimethylpyridine, 4-dimethylaminopyridine, 1,4-diazabicyclo[2.2.2]octane, 1,8-diazabicyclo[5.4.0]undec-7-ene, and 1,5-diazabicyclo[4.3.0]undec-7-ene, and inorganic bases such as potassium carbonate, potassium hydroxide, potassium hydrogen carbonate, sodium carbonate, sodium hydroxide, sodium hydrogen carbonate, sodium acetate, potassium acetate, sodium methoxide, sodium ethoxide, and potassium tert-butoxide; preferably triethylamine, tributylamine, diisopropylethylamine, potassium carbonate, potassium hydroxide, potassium hydrogen carbonate, sodium carbonate, sodium hydroxide, sodium hydrogen carbonate, sodium acetate, and potassium acetate; and more preferably triethylamine, diisopropylethylamine, and N-methylmorpholine.

[0217]

The solvent used in this step is not particularly limited as long as it does not inhibit the reaction, and examples include acetonitrile, dichloromethane,

chloroform, methanol, ethanol, diethyl ether, 1,2-dimethoxyethane, tetrahydrofuran, 2-methyltetrahydrofuran, 1,4-dioxane, ethyl acetate, hexane, pentane, heptane, cyclohexane, ethylcyclohexane, benzene, toluene, chlorobenzene, acetone, 2-butanone, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof, and preferably acetonitrile, dichloromethane, methanol, tetrahydrofuran, 1,4-dioxane, N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, dimethyl sulfoxide, and water, and mixed solvents thereof.

[0218]

[Production of antibody]

[0219]

An antibody for use in the production of the antibody-drug conjugate of the present invention may be derived from any species, and is preferably an antibody derived from a human, a rat, a mouse, or a rabbit. In cases where the antibody is derived from species other than human species, it is preferably chimerized or humanized using a well-known technique. The antibody of the present invention may be a polyclonal antibody or a monoclonal antibody and is preferably a monoclonal antibody.

[0220]

The antibody for use in the production of the antibody-drug conjugate of the present invention is an

antibody preferably having a characteristic of being capable of targeting cancer cells, and is preferably an antibody possessing, for example, the property of recognizing a cancer cell, the property of binding to a cancer cell, the property of internalizing in a cancer cell, and/or cytocidal activity against cancer cells.

[0221]

The binding activity of the antibody against cancer cells can be confirmed using flow cytometry. The internalization of the antibody into tumor cells can be confirmed using (1) an assay of visualizing an antibody incorporated in cells under a fluorescence microscope using a secondary antibody (fluorescently labeled) binding to the therapeutic antibody (Cell Death and Differentiation (2008) 15, 751-761), (2) an assay of measuring a fluorescence intensity incorporated in cells using a secondary antibody (fluorescently labeled) binding to the therapeutic antibody (Molecular Biology of the Cell, Vol. 15, 5268-5282, December 2004), or (3) a Mab-ZAP assay using an immunotoxin binding to the therapeutic antibody wherein the toxin is released upon incorporation into cells to inhibit cell growth (Bio Techniques 28: 162-165, January 2000). As the immunotoxin, a recombinant complex protein of a diphtheria toxin catalytic domain and protein G may be used.

[0222]

The antitumor activity of the antibody can be confirmed in vitro by determining inhibitory activity against cell growth. For example, a cancer cell line overexpressing a target protein for the antibody is cultured, and the antibody is added into the culture system at varying concentrations to determine inhibitory activity against focus formation, colony formation, and spheroid growth. The antitumor activity can be confirmed in vivo, for example, by administering the antibody to a nude mouse with a transplanted cancer cell line highly expressing the target protein, and determining change in the cancer cell.

[0223]

Since the compound conjugated in the antibody-drug conjugate exerts an antitumor effect, it is preferred but not essential that the antibody itself should have an antitumor effect. For the purpose of specifically and selectively exerting the cytotoxic activity of the antitumor compound against cancer cells, it is important and also preferred that the antibody should have the property of internalizing to migrate into cancer cells.

[0224]

The antibody for use in the production of the antibody-drug conjugate of the present invention can be obtained by a procedure known in the art. For example, the antibody of the present invention can be obtained using a method usually carried out in the art, which

involves immunizing animals with an antigenic polypeptide and collecting and purifying antibodies produced in vivo. The origin of the antigen is not limited to humans, and the animals may be immunized with an antigen derived from a non-human animal such as a mouse, a rat and the like. In this case, the cross-reactivity of antibodies binding to the obtained heterologous antigen with human antigens can be tested to screen for an antibody applicable to a human disease.

[0225]

Alternatively, antibody-producing cells which produce antibodies against the antigen are fused with myeloma cells according to a method known in the art (e.g., Kohler and Milstein, *Nature* (1975) 256, p. 495-497; and Kennet, R. ed., *Monoclonal Antibodies*, p. 365-367, Plenum Press, N.Y. (1980)) to establish hybridomas, from which monoclonal antibodies can in turn be obtained.

[0226]

The antigen can be obtained by genetically engineering host cells to produce a gene encoding the antigenic protein. Specifically, vectors that permit expression of the antigen gene are prepared and transferred to host cells so that the gene is expressed. The antigen thus expressed can be purified. The antibody can also be obtained by a method of immunizing animals with the above-described genetically engineered antigen-expressing cells or a cell line expressing the antigen.

[0227]

The antibody for use in the production of the antibody-drug conjugate of the present invention is preferably a recombinant antibody obtained by artificial modification for the purpose of decreasing heterologous antigenicity to humans such as a chimeric antibody or a humanized antibody, or is preferably an antibody having only the gene sequence of an antibody derived from a human, that is, a human antibody. These antibodies can be produced using a known method.

[0228]

As the chimeric antibody, an antibody in which antibody variable and constant regions are derived from different species, for example, a chimeric antibody in which a mouse- or rat-derived antibody variable region is connected to a human-derived antibody constant region can be exemplified (Proc. Natl. Acad. Sci. USA, 81, 6851-6855, (1984)).

[0229]

As the humanized antibody, an antibody obtained by integrating only the complementarity determining region (CDR) of a heterologous antibody into a human-derived antibody (Nature (1986) 321, pp. 522-525), an antibody obtained by grafting a part of the amino acid residues of the framework of a heterologous antibody as well as the CDR sequence of the heterologous antibody to a human antibody by a CDR-grafting method (International

Publication No. WO 90/07861), and an antibody humanized using a gene conversion mutagenesis strategy (U.S. Patent No. 5821337) can be exemplified.

[0230]

As the human antibody, an antibody generated by using a human antibody-producing mouse having a human chromosome fragment including genes of a heavy chain and light chain of a human antibody (see Tomizuka, K. et al., Nature Genetics (1997) 16, p.133-143; Kuroiwa, Y. et. al., Nucl. Acids Res. (1998) 26, p.3447-3448; Yoshida, H. et. al., Animal Cell Technology: Basic and Applied Aspects vol.10, p.69-73 (Kitagawa, Y., Matsuda, T. and Iijima, S. eds.), Kluwer Academic Publishers, 1999; Tomizuka, K. et. al., Proc. Natl. Acad. Sci. USA (2000) 97, p.722-727, etc.) can be exemplified. As an alternative, an antibody obtained by phage display, the antibody being selected from a human antibody library (see Wormstone, I. M. et. al, Investigative Ophthalmology & Visual Science. (2002)43 (7), p.2301-2308; Carmen, S. et. al., Briefings in Functional Genomics and Proteomics (2002), 1(2), p.189-203; Siriwardena, D. et. al., Ophthalmology (2002) 109(3), p.427-431, etc.) can be exemplified.

[0231]

In the present invention, modified variants of the antibody for use in the production of the antibody-drug conjugate of the present invention are also included. The modified variant refers to a variant obtained by

subjecting the antibody according to the present invention to chemical or biological modification. Examples of the chemically modified variant include variants including a linkage of a chemical moiety to an amino acid skeleton, variants including a linkage of a chemical moiety to an N-linked or O-linked carbohydrate chain, etc. Examples of the biologically modified variant include variants obtained by post-translational modification (such as N-linked or O-linked glycosylation, N- or C-terminal processing, deamidation, isomerization of aspartic acid, or oxidation of methionine), and variants in which a methionine residue has been added to the N terminus by being expressed in a prokaryotic host cell. Further, an antibody labeled so as to enable the detection or isolation of the antibody or an antigen according to the present invention, for example, an enzyme-labeled antibody, a fluorescence-labeled antibody, and an affinity-labeled antibody are also included in the meaning of the modified variant. Such a modified variant of the antibody according to the present invention is useful for improving the stability and blood retention of the antibody, reducing the antigenicity thereof, detecting or isolating an antibody or an antigen, and so on.

[0232]

Further, by regulating the modification of a glycan which is linked to the antibody according to the present

invention (glycosylation, defucosylation, etc.), it is possible to enhance antibody-dependent cellular cytotoxic activity. As the technique for regulating the modification of a glycan of antibodies, International Publication No. WO 99/54342, International Publication No. WO 00/61739, International Publication No. WO 02/31140, etc. are known. However, the technique is not limited thereto. In the antibody according to the present invention, antibodies in which the modification of a glycan is regulated are also included.

[0233]

It is known that a lysine residue at the carboxyl terminus of the heavy chain of an antibody produced in a cultured mammalian cell is deleted (Journal of Chromatography A, 705: 129-134 (1995)), and it is also known that two amino acid residues (glycine and lysine) at the carboxyl terminus of the heavy chain of an antibody produced in a cultured mammalian cell are deleted and a proline residue newly located at the carboxyl terminus is amidated (Analytical Biochemistry, 360: 75-83 (2007)). However, such deletion and modification of the heavy chain sequence do not affect the antigen-binding affinity and the effector function (the activation of complement, antibody-dependent cellular cytotoxicity, etc.) of the antibody. Therefore, in the antibody according to the present invention, antibodies subjected to such modification and functional

fragments of the antibody are also included, and deletion variants in which one or two amino acids have been deleted at the carboxyl terminus of the heavy chain, variants obtained by amidation of deletion variants (for example, a heavy chain in which the carboxyl terminal proline residue has been amidated), and the like are also included. The type of deletion variant having a deletion at the carboxyl terminus of the heavy chain of the antibody according to the present invention is not limited to the above variants as long as the antigen-binding affinity and the effector function are conserved. The two heavy chains constituting the antibody according to the present invention may be of one type selected from the group consisting of a full-length heavy chain and the above-described deletion variant, or may be of two types in combination selected therefrom. The ratio of the amount of each deletion variant can be affected by the type of cultured mammalian cells which produce the antibody according to the present invention and the culture conditions; however, an antibody in which one amino acid residue at the carboxyl terminus has been deleted in both of the two heavy chains in the antibody according to the present invention can be preferably exemplified.

[0234]

As isotypes of the antibody according to the present invention, for example, IgG (IgG1, IgG2, IgG3, IgG4) can

be exemplified, and IgG1 or IgG2 can be exemplified preferably.

[0235]

Examples of antibodies applicable to the production of the antibody-drug conjugate of the present invention can include, but are not particularly limited to, an anti-HER2 antibody, an anti-HER3 antibody, an anti-TROP2 antibody, an anti-B7-H3 antibody, an anti-CD3 antibody, an anti-CD30 antibody, an anti-CD33 antibody, an anti-CD37 antibody, an anti-CD56 antibody, an anti-CD98 antibody, an anti-DR5 antibody, an anti-EGFR antibody, an anti-EPHA2 antibody, an anti-FGFR2 antibody, an anti-FGFR4 antibody, an anti-FOLR1 antibody, an anti-VEGF antibody, and an anti-GPR20 antibody, and preferably an anti-HER2 antibody, an anti-HER3 antibody, an anti-TROP2 antibody, an anti-B7-H3 antibody, and an anti-GPR20 antibody can be exemplified.

[0236]

In the present invention, the term "anti-HER2 antibody" refers to an antibody which specifically binds to HER2 (Human Epidermal Growth Factor Receptor Type 2; ErbB-2), and preferably has an activity of internalizing in HER2-expressing cells by binding to HER2.

[0237]

Examples of the anti-HER2 antibody include trastuzumab (U.S. Patent No. 5821337) and pertuzumab

(International Publication No. WO 01/00245), and trastuzumab can be preferably exemplified.

[0238]

In the present invention, the term "trastuzumab" is a humanized anti-HER2 monoclonal antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 1 to 449 of SEQ ID NO: 1 (Figure 1) and a light chain consisting of an amino acid sequence consisting of amino acid residues 1 to 214 of SEQ ID NO: 2 (Figure 2).

[0239]

In the present invention, the term "anti-HER3 antibody" refers to an antibody which specifically binds to HER3 (Human Epidermal Growth Factor Receptor Type 3; ErbB-3), and preferably has an activity of internalizing in HER3-expressing cells by binding to HER3 on the surface of the HER3-expressing cells.

[0240]

Examples of the anti-HER3 antibody include patritumab (U3-1287), U1-59 (International Publication No. WO 2007/077028), MM-121 (seribantumab), an anti-ERBB3 antibody described in International Publication No. WO 2008/100624, RG-7116 (lumretuzumab), and LJM-716 (elgentumab), and patritumab and U1-59 can be preferably exemplified.

[0241]

In the present invention, the term "anti-TROP2 antibody" refers to an antibody which specifically binds to TROP2 (TACSTD2: Tumor-associated calcium signal transducer 2; EGP-1), and preferably has an activity of internalizing in TROP2-expressing cells by binding to TROP2.

[0242]

Examples of the anti-TROP2 antibody include hTINA1-H1L1 (International Publication No. WO 2015/098099).

[0243]

In the present invention, the term "anti-B7-H3 antibody" refers to an antibody which specifically binds to B7-H3 (B cell antigen #7 homolog 3; PD-L3; CD276), and preferably has an activity of internalizing in B7-H3-expressing cells by binding to B7-H3.

[0244]

Examples of the anti-B7-H3 antibody include M30-H1-L4 (International Publication No. WO 2014/057687).

[0245]

In the present invention, the term "anti-GPR20 antibody" refers to an antibody which specifically binds to GPR20 (G protein-coupled receptor 20), and preferably has an activity of internalizing in GPR20-expressing cells by binding to GPR20.

Examples of the anti-GPR20 antibody include h046-H4e/L7 (International Publication No. WO 2018/135501).

[0246]

[Conjugation between the antibody and the drug-linker intermediate]

[0247]

The antibody-drug conjugate according to the present invention can be produced by reacting a drug-linker intermediate (preferably the compound represented by formula (14)) and an antibody having a thiol group (alternatively referred to as a sulfhydryl group).

[0248]

The antibody having a sulfhydryl group can be obtained by a method well known in the art (Hermanson, G. T, Bioconjugate Techniques, pp. 56-136, pp. 456-493, Academic Press (1996)). For example, by using 0.3 to 3 molar equivalents of a reducing agent such as tris(2-carboxyethyl)phosphine hydrochloride (TCEP) per interchain disulfide within the antibody and reacting with the antibody in a buffer solution containing a chelating agent such as ethylenediamine tetraacetic acid (EDTA), an antibody having a sulfhydryl group with partially or completely reduced interchain disulfides within the antibody can be obtained.

[0249]

Further, by using 2 to 20 molar equivalents of the drug-linker intermediate (preferably the compound represented by formula (14)) per antibody having a sulfhydryl group, an antibody-drug conjugate in which 2

to 8 drug molecules are conjugated per antibody molecule can be produced.

[0250]

The average number of conjugated drug molecules per antibody molecule of the antibody-drug conjugate produced can be determined, for example, by a method of calculation based on measurement of UV absorbance for the antibody-drug conjugate and the conjugation precursor thereof at two wavelengths of 280 nm and 370 nm (UV method), or a method of calculation based on quantification through HPLC measurement for fragments obtained by treating the antibody-drug conjugate with a reducing agent (HPLC method).

[0251]

Conjugation between the antibody and the drug-linker intermediate and calculation of the average number of conjugated drug molecules per antibody molecule of the antibody-drug conjugate can be performed with reference to descriptions in International Publication No. WO 2014/057687, International Publication No. WO 2015/098099, International Publication No. WO 2015/115091, International Publication No. WO 2015/155998, International Publication No. WO 2018/135501, and so on.

[0252]

In the present invention, the term "anti-HER2 antibody-drug conjugate" refers to an antibody-drug

conjugate in which the antibody in the antibody-drug conjugate is an anti-HER2 antibody.

[0253]

The anti-HER2 antibody is preferably an antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 1 to 449 of SEQ ID NO: 1 and a light chain consisting of an amino acid sequence consisting of amino acid residues 1 to 214 of SEQ ID NO: 2; or an antibody comprising a heavy chain consisting of the amino acid sequence represented by SEQ ID NO: 1 and a light chain consisting of the amino acid sequence represented by SEQ ID NO: 2.

[0254]

The average number of units of the drug-linker conjugated per antibody molecule in the anti-HER2 antibody-drug conjugate produced by the present invention is preferably 2 to 8, more preferably 3 to 8, even more preferably 7 to 8, even more preferably 7.5 to 8, and even more preferably about 8.

[0255]

The anti-HER2 antibody-drug conjugate can be produced with reference to descriptions in International Publication No. WO 2015/115091 by using a drug-linker² intermediate (preferably the compound represented by formula (14)) produced by the production method of the present invention.

[0256]

In the present invention, the term "anti-HER3 antibody-drug conjugate" refers to an antibody-drug conjugate in which the antibody in the antibody-drug conjugate is an anti-HER3 antibody.

[0257]

The anti-HER3 antibody is preferably an antibody comprising a heavy chain consisting of the amino acid sequence represented by SEQ ID NO: 3 and a light chain consisting of the amino acid sequence represented by SEQ ID NO: 4, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[0258]

The average number of units of the drug-linker conjugated per antibody molecule in the anti-HER3 antibody-drug conjugate produced by the present invention is preferably 2 to 8, more preferably 3 to 8, even more preferably 7 to 8, even more preferably 7.5 to 8, and even more preferably about 8.

[0259]

The anti-HER3 antibody-drug conjugate can be produced with reference to descriptions in International Publication No. WO 2015/155998 by using a drug-linker intermediate (preferably the compound represented by formula (14)) produced by the production method of the present invention.

[0260]

In the present invention, the term "anti-TROP2 antibody-drug conjugate" refers to an antibody-drug conjugate in which the antibody in the antibody-drug conjugate is an anti-TROP2 antibody.

[0261]

The anti-TROP2 antibody is preferably an antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 20 to 470 of SEQ ID NO: 5 and a light chain consisting of an amino acid sequence consisting of amino acid residues 21 to 234 of SEQ ID NO: 6, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[0262]

The average number of units of the drug-linker conjugated per antibody molecule in the anti-TROP2 antibody-drug conjugate produced by the present invention is preferably 2 to 8, more preferably 3 to 5, even more preferably 3.5 to 4.5, and even more preferably about 4.

[0263]

The anti-TROP2 antibody-drug conjugate can be produced with reference to descriptions in International Publication No. WO 2015/098099 by using a drug-linker intermediate (preferably the compound represented by formula (14)) produced by the production method of the present invention.

[0264]

In the present invention, the term "anti-B7-H3 antibody-drug conjugate" refers to an antibody-drug conjugate in which the antibody in the antibody-drug conjugate is an anti-B7-H3 antibody.

[0265]

The anti-B7-H3 antibody is preferably an antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 20 to 471 of SEQ ID NO: 7 and a light chain consisting of an amino acid sequence consisting of amino acid residues 21 to 233 of SEQ ID NO: 8, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[0266]

The average number of units of the drug-linker conjugated per antibody molecule in the anti-B7-H3 antibody-drug conjugate produced by the present invention is preferably 2 to 8, more preferably 3 to 5, even more preferably 3.5 to 4.5, and even more preferably about 4.

[0267]

The anti-B7-H3 antibody-drug conjugate can be produced with reference to descriptions in International Publication No. WO 2014/057687 by using a drug-linker intermediate (preferably the compound represented by formula (14)) produced by the production method of the present invention.

[0268]

In the present invention, the term "anti-GPR20 antibody-drug conjugate" refers to an antibody-drug conjugate in which the antibody in the antibody-drug conjugate is an anti-GPR20 antibody.

[0269]

The anti-GPR20 antibody is preferably an antibody comprising a heavy chain consisting of an amino acid sequence consisting of amino acid residues 20 to 472 of SEQ ID NO: 9 and a light chain consisting of an amino acid sequence consisting of amino acid residues 21 to 234 of SEQ ID NO: 10, or a variant of the antibody in which a lysine residue at the carboxyl terminus of the heavy chain is deleted.

[0270]

The average number of units of the drug-linker conjugated per antibody molecule in the anti-GPR20 antibody-drug conjugate produced by the present invention is preferably 2 to 8, more preferably 3 to 8, even more preferably 7 to 8, even more preferably 7.5 to 8, and even more preferably about 8.

[0271]

The anti-GPR20 antibody-drug conjugate can be produced with reference to descriptions in International Publication No. WO 2018/135501 by using a drug-linker intermediate (preferably the compound represented by formula (14)) produced by the production method of the present invention.

[0272]

[Pharmaceutical compositions]

The antibody-drug conjugate produced by the present invention can contain at least one pharmaceutically suitable ingredient and be administered. The pharmaceutically suitable ingredient can be suitably selected and applied from formulation additives or the like that are generally used in the art according to the dosage, administration concentration, and so on of the antibody-drug conjugate produced by the present invention. For example, the antibody-drug conjugate produced by the present invention can be administered as a pharmaceutical composition containing a buffer such as a histidine buffer, an excipient such as sucrose or trehalose, and a surfactant such as polysorbate 80 or polysorbate 20.

[0273]

The pharmaceutical composition containing the antibody-drug conjugate produced by the present invention can be expected to exert a therapeutic effect by application as a systemic therapy to patients, and additionally, by local application to cancer tissues.

[0274]

The pharmaceutical composition containing the antibody-drug conjugate produced by the present invention can be preferably used for a mammal, and can be more preferably used for a human.

[0275]

The pharmaceutical composition containing the antibody-drug conjugate produced by the present invention can be preferably used as an injection, can be more preferably used as an aqueous injection or a lyophilized injection, and can be even more preferably used as a lyophilized injection.

[0276]

In the case that the pharmaceutical composition containing the antibody-drug conjugate produced by the present invention is an aqueous injection, preferably it can be diluted with a suitable diluent and then intravenously administered by drip infusion. Examples of the diluent include glucose solution (preferably a 5% glucose solution) and physiological saline.

[0277]

In the case that the pharmaceutical composition containing the antibody-drug conjugate produced by the present invention is a lyophilized injection, preferably it can be dissolved in water for injection, and then, a necessary amount can be diluted with a suitable diluent and then intravenously administered by drip infusion. Examples of the diluent include a glucose solution (preferably a 5% glucose solution) and physiological saline.

[0278]

Examples of administration routes that can be used for administering the pharmaceutical composition

containing the antibody-drug conjugate produced by the invention can include intravenous, intradermal, subcutaneous, intramuscular, and intraperitoneal routes, and intravenous route can be preferably exemplified.

[0279]

The antibody-drug conjugate produced by the present invention can be administered to a human at intervals of once a day to every 180 days, preferably can be administered at intervals of once a week, every 2 weeks, every 3 weeks, or every 4 weeks, and even more preferably can be administered at intervals of once every 3 weeks. Also, the antibody-drug conjugate produced by the present invention can be administered at a dosage of about 0.001 to 100 mg/kg per dose, and preferably administered at a dosage of 0.8 to 12.4 mg/kg per dose. In the case that the antibody-drug conjugate produced by the present invention is an anti-HER2 antibody-drug conjugate, it can be preferably administered at a dosage of 5.4, 6.4, or 7.4 mg/kg per dose, and more preferably can be administered at a dosage of 5.4 mg/kg or 6.4 mg/kg per dose.

[0280]

The pharmaceutical composition containing the antibody-drug conjugate produced by the present invention can be used for treating cancer, and can be preferably used for treating at least one type of cancer selected from the group consisting of breast cancer, stomach

cancer (also called gastric adenocarcinoma), colorectal cancer (also called colon and rectal cancer, and including colon cancer and rectal cancer), lung cancer (including small cell lung cancer and non-small cell lung cancer), esophageal cancer, salivary gland cancer, esophagogastric junction adenocarcinoma, bile duct cancer, Paget's disease, pancreatic cancer, ovarian cancer, uterine carcinosarcoma, urothelial cancer, prostate cancer, bladder cancer, gastrointestinal stromal tumor, digestive tract stromal tumor, cervical cancer, squamous cell carcinoma, peritoneal cancer, liver cancer, hepatocellular cancer, colon cancer, rectal cancer, endometrial cancer, uterine cancer, kidney cancer, vulvar cancer, thyroid cancer, penile cancer, leukemia, malignant lymphoma, plasmacytoma, myeloma, neuroepithelial tumor, nerve sheath tumor, head-and-neck cancer, skin cancer, pharyngeal cancer, gallbladder cancer, bile duct cancer, mesothelioma, and sarcoma. For example, when the antibody-drug conjugate produced by the present invention is an anti-HER2 antibody-drug conjugate, the antibody-drug conjugate can be more preferably used for treating at least one type of cancer selected from the group consisting of breast cancer, stomach cancer, colorectal cancer, non-small cell lung cancer, esophageal cancer, salivary gland cancer, esophagogastric junction adenocarcinoma, bile duct cancer, Paget's disease, pancreatic cancer, ovarian cancer, and uterine

carcinosarcoma, can be more preferably used for treating at least one type of cancer selected from the group consisting of breast cancer, stomach cancer, colorectal cancer, non-small cell lung cancer, esophageal cancer, salivary gland cancer, gastroesophageal junction adenocarcinoma, bile duct cancer, and Paget's disease, and can be even more preferably used for treating breast cancer, stomach cancer, colorectal cancer, or non-small cell lung cancer.

[0281]

The pharmaceutical composition containing the antibody-drug conjugate produced by the present invention can be selectively used as an agent for drug therapy, which is a main method for treating cancer, and as a result, can delay development of cancer cells, inhibit growth thereof, and further kill cancer cells. These effects can allow cancer patients to be free from symptoms caused by cancer or achieve improvement in QOL of cancer patients and attain a therapeutic effect by sustaining the lives of the cancer patients. Even if the pharmaceutical composition and therapeutic method of the present invention do not accomplish killing cancer cells, they can achieve higher QOL of cancer patients while achieving longer-term survival, by inhibiting or controlling the growth of cancer cells.

[0282]

In such drug therapy, the pharmaceutical composition containing the antibody-drug conjugate produced by the present invention can be used as an agent alone and, in addition, can also be used in combination with an additional therapy in adjuvant therapy and can be combined with surgery, radiotherapy, hormone therapy, or the like. Furthermore, the pharmaceutical composition can also be used as drug therapy in neoadjuvant therapy.

[0283]

In addition to the therapeutic use as described above, for example, a prophylactic effect such as suppressing the growth of small metastatic cancer cells and further killing them can also be expected for the pharmaceutical composition containing the antibody-drug conjugate produced by the present invention. For example, an effect of inhibiting and killing cancer cells in a body fluid in the course of metastasis or an effect of, for example, inhibiting and killing small cancer cells immediately after implantation in any tissue can be expected. Accordingly, inhibition of cancer metastasis or a prophylactic effect can be expected, particularly, after surgical removal of cancer.

[0284]

The pharmaceutical composition containing the antibody-drug conjugate produced by the present invention can be administered in combination with other cancer treating agents. The anti-cancer effect may be enhanced

accordingly. Examples of other cancer treating agents used in such purposes include 5-fluorouracil (5-FU), pertuzumab, trastuzumab, paclitaxel, carboplatin, cisplatin, gemcitabine, capecitabine, irinotecan (CPT-11), docetaxel, pemetrexed, sorafenib, vinblastin, vinorelbine, everolimus, tanespimycin, bevacizumab, oxaliplatin, lapatinib, trastuzumab emtansine (T-DM1) or agents described in International Publication No. WO 2003/038043, LH-RH analogues (leuprorelin, goserelin, or the like), estramustine phosphate, estrogen antagonists (tamoxifen, raloxifene, or the like), and aromatase inhibitors (anastrozole, letrozole, exemestane, and the like), but are not limited as long as they are agents having an antitumor activity.

Examples

[0285]

The present invention is described in more detail below by way of examples. However, the present invention is not limited to these.

In the Examples, the terms "¹H-NMR" and "¹³C-NMR" mean "nuclear magnetic resonance spectrum". Within parentheses, CDCl₃ means deuterated chloroform which is a measuring solvent, DMSO-d₆ means deuterated dimethyl sulfoxide which is a measuring solvent, and D₂O means deuterium oxide which is a measuring solvent. TMS (tetramethylsilane) was used as an internal standard.

The meanings of multiplicity in ^1H -NMR are s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, m = multiplet, and brs = broad singlet.

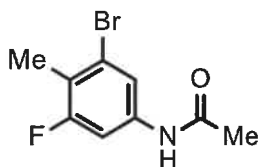
[0286]

(Example 1)

N-(3-Bromo-5-fluoro-4-methylphenyl)acetamide

[0287]

[Chem. 62]



(6)

[0288]

A solution of 2-fluoro-1-methyl-4-nitrobenzene (10.0 g, 64.5 mmol) in concentrated sulfuric acid (90% or more, 50 mL) and heptane (50 mL) was heated to about 60°C, and then N-bromosuccinimide (13.8 g, 77.4 mmol) was added in six divided portions. The mixture was stirred at about 60°C for 1 hour and then cooled to room temperature. The resulting reaction solution was added to cold water (50 mL). After toluene (50 mL) was added for separation, the aqueous layer was removed. Then, the organic layer was washed with water (50 mL), a 6.5 wt% aqueous sodium hydrogencarbonate solution (50 mL), and a 5 wt% aqueous sodium sulfite solution (50 mL). Water (50 mL) and activated carbon (1.0 g) were added to the resulting aqueous layer, the mixture was stirred for 1 hour at room

temperature, and then insoluble matter was separated by filtration and washed with toluene (20 mL). After the aqueous layer was removed from the filtrate, the organic layer was concentrated under reduced pressure. Ethyl acetate (100 mL) was added to the concentrated residue (about 30 mL), and the mixture was concentrated again under reduced pressure to give a solution of 1-bromo-3-fluoro-2-methyl-5-nitrobenzene in ethyl acetate (about 30 mL).

[0289]

A suspension was obtained by adding a 1% platinum carbon catalyst (2.0 g) and ethyl acetate (120 mL) to the solution of 1-bromo-3-fluoro-2-methyl-5-nitrobenzene in ethyl acetate (about 30 mL) and the atmosphere was replaced with nitrogen and then replaced with hydrogen. The mixture was stirred at about 60°C for 4 hours in a hydrogen stream (0.1 MPa) and cooled to room temperature. Insoluble matter was separated by filtration from the resulting suspension, and the insoluble matter was washed with ethyl acetate (30 mL). The filtrate was washed twice with a 0.5 N hydrochloric acid solution (100 mL) to give an organic layer. The aqueous layer at this time was extracted with ethyl acetate (50 mL) to give an organic layer, and the organic layers were combined. Then, the organic layer was washed with a 6.5 wt% aqueous sodium hydrogencarbonate solution (50 mL) and 5 wt% brine (50 mL), and the resulting organic layer was concentrated

under reduced pressure. Ethyl acetate (50 mL) was added to the concentrated residue (about 30 mL), and the mixture was concentrated again under reduced pressure to give a solution of 3-bromo-5-fluoro-4-methylaniline in ethyl acetate (about 30 mL).

Triethylamine (7.2 mL, 51.8 mmol) and acetic anhydride (3.3 mL, 34.4 mmol) were added to a solution obtained by adding ethyl acetate (30 mL) to the solution of 3-bromo-5-fluoro-4-methylaniline in ethyl acetate (about 29 mL), and the mixture was stirred at room temperature for 6 hours. After 10 wt% brine (50 mL) was added to the resulting reaction solution for separation, the aqueous layer was removed. The resulting organic layer was concentrated under reduced pressure, then ethyl acetate (50 mL) was added, and the mixture was concentrated again under reduced pressure. Ethyl acetate (80 mL) was added to the concentrated residue (about 30 mL), a 4 N hydrochloric acid/ethyl acetate solution (10.9 mL, 43.7 mmol) was added, and then the mixture was stirred at room temperature for 1 hour. Insoluble matter was separated by filtration and washed with ethyl acetate (40 mL). After 10 wt% brine (40 mL) was added to the filtrate, a 25 wt% aqueous sodium hydroxide solution (5.6 g) was added to regulate the pH to about 7. After the aqueous layer was removed, the organic layer was concentrated under reduced pressure. Toluene (100 mL) was added to the concentrated residue (about 30 mL), and

the concentrated residue (about 30 mL) concentrated under reduced pressure was stirred at 50°C for 5 hours and then cooled to room temperature. The mixture was stirred at room temperature for 12 hours, then cooled to 3°C, and stirred for 2 hours. The precipitated crystals were collected by filtration and washed with cold toluene (20 mL) and 75% cold aqueous acetonitrile (20 mL). The resulting crystals were dried at 40°C under reduced pressure to give N-(3-bromo-5-fluoro-4-methylphenyl)acetamide as white crystals (5.7 g, yield 37%).

[0290]

¹H-NMR (500 MHz, CDCl₃) δ 7.41 (1H, s), 7.39 (1H, d, J=9.2 Hz), 7.20 (1H, brs), 2.27 (3H, d, J=2.0 Hz), 2.17 (3H, s)

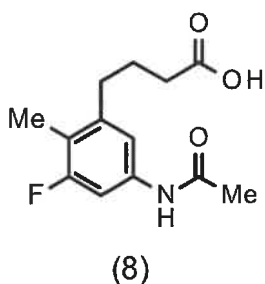
[0291]

(Example 2)

4-[5-(Acetylamino)-3-fluoro-2-methylphenyl]butanoic acid

[0292]

[Chem. 63]



[0293]

A solution of N-(3-bromo-5-fluoro-4-methylphenyl)acetamide (30.0 g, 121.9 mmol), 3-butenic acid (12.4 mL, 146.3 mmol), and diisopropylethylamine (46.0 mL, 268.2 mmol) in tetrahydrofuran (120 mL) and water (30 mL) was degassed under reduced pressure and the atmosphere was replaced with nitrogen, and then tri(o-tolyl)phosphine (1.1 g, 3.7 mmol) was added. Again the mixture was degassed under reduced pressure and the atmosphere was replaced with nitrogen, then palladium(II) acetate (0.4 g, 1.8 mmol) was added, and the mixture was degassed under reduced pressure, the atmosphere was replaced with nitrogen, and then thermally refluxed for 5 hours. Activated carbon (3.0 g) was added to the reaction solution that had been cooled to room temperature, and the mixture was stirred at room temperature for 1 hour. Insoluble matter was separated by filtration and washed with 20% aqueous tetrahydrofuran (60 mL). 2-Methyltetrahydrofuran (300 mL) and water (300 mL) were added to the filtrate, and a 25 wt% aqueous sodium hydroxide solution (23.4 g, 146.3 mmol) was added. The organic layer was removed, 2-methyltetrahydrofuran (300 mL) and concentrated hydrochloric acid (36%, 22.2 g, 219.4 mmol) were added to the aqueous layer, and then sodium chloride (30 g) was added. After separation, the aqueous layer was removed, and the organic layer was washed with 10 wt% brine (90 mL). The resulting organic layer was concentrated under reduced pressure to give a

solution of 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]-3-butenic acid containing geometric isomers in 2-methyltetrahydrofuran (about 150 mL).

[0294]

A suspension was obtained by adding 2-methyltetrahydrofuran (308 mL) and 5% palladium carbon (5.6 g) to the solution of 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]-3-butenic acid containing geometric isomers in 2-methyltetrahydrofuran (about 140 mL) and the atmosphere was replaced with nitrogen and then replaced with hydrogen. The mixture was stirred at about 40°C for 1 hour in a hydrogen stream (0.1 MPa) and cooled to room temperature. Insoluble matter was separated by filtration from the resulting suspension and washed with 2-methyltetrahydrofuran (112 mL). Water (140 mL) was added to the filtrate, and the pH was regulated to about 2 with a 1 N hydrochloric acid solution. After separation, the aqueous layer was removed, and the resulting organic layer was concentrated under reduced pressure. Ethyl acetate (420 mL) was added to the concentrated residue, and the mixture was concentrated under reduced pressure. Again, ethyl acetate (420 mL) was added, and the mixture was concentrated under reduced pressure to give a concentrated residue (about 170 mL). After the concentrated residue was stirred at 50°C for 5 hours, heptane (140 mL) was added, and the mixture was cooled to room temperature. The precipitated crystals

were collected by filtration and washed with ethyl acetate/heptane (3/7) (84 mL). The resulting crystals were dried under reduced pressure to give 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]butanoic acid as white crystals (26.1 g, yield 91%).

[0295]

¹H-NMR (500 MHz, DMSO-d₆) δ 12.08 (1H, brs), 9.97 (1H, s), 7.42 (1H, dd, J=12.5, 2.0 Hz), 7.05 (1H, d, J=1.5 Hz), 2.59-2.54 (2H, m), 2.28 (2H, t, J=7.3 Hz), 2.10 (3H, d, J=2.0 Hz), 2.02 (3H, s), 1.71 (2H, quint, J=7.5 Hz)

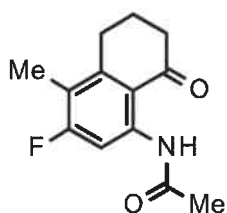
[0296]

(Example 3-1)

N-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide

[0297]

[Chem. 64]



(9)

[0298]

After a solution of 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]butanoic acid (12.0 g, 47.4 mmol) and trifluoroacetic acid (24 mL) was cooled to 4°C, trifluoroacetic anhydride (13.4 mL, 94.8 mmol) was added dropwise, and the mixture was stirred at about 4°C for 4

hours. The resulting reaction solution was added dropwise to 50% aqueous acetonitrile (120 mL) that had been cooled to 5°C. After the pH was regulated to about 7 with a 25 wt% aqueous sodium hydroxide solution (77.3 g), water (59 mL) was added. Then, the temperature was returned to room temperature, and the precipitated crystals were collected by filtration and washed with water (60 mL) and 75% aqueous acetonitrile (60 mL). The resulting crystals were dried under reduced pressure to give N-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide as pale yellowish white crystals (10.2 g, yield 92%).

[0299]

¹H-NMR (400 MHz, CDCl₃) δ 12.31 (1H, brs), 8.43 (1H, d, J=12.8 Hz), 2.88 (2H, t, J=12.0 Hz), 2.66 (2H, dd, J=7.2, 6.0 Hz), 2.22 (3H, s), 2.17 (3H, d, J=2.0 Hz), 2.09 (3H, quint, J=6.4 Hz)

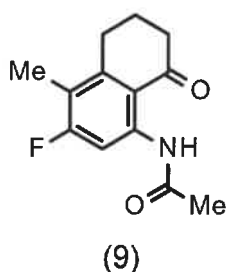
[0300]

(Example 3-2)

N-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide

[0301]

[Chem. 65]



[0302]

After a solution of 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]butanoic acid (5.0 g, 19.7 mmol) and trifluoroacetic acid (10 mL) was cooled to 2°C, trifluoroacetic anhydride (5.6 mL, 39.5 mmol) was added dropwise, and the mixture was stirred at about 5°C for 3 hours. To the reaction solution 50% aqueous acetonitrile (50 mL) was added dropwise. After the pH was regulated to about 7 with a 25 w/v% aqueous sodium hydroxide solution (33 mL), water (17 mL) was added. Then, the temperature was returned to room temperature, and the precipitated crystals were collected by filtration and washed with water (25 mL) and 75% aqueous acetonitrile (25 mL). The resulting crystals were dried under reduced pressure to give N-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide as pale yellowish white crystals (4.3 g, yield 92%).

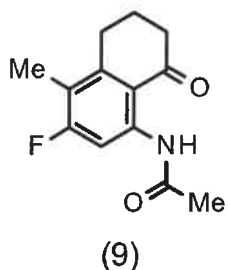
[0303]

(Example 3-3)

N-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide

[0304]

[Chem. 66]



[0305]

After a solution of 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]butanoic acid (5.0 g, 19.7 mmol) and trifluoroacetic acid (10 mL) was cooled to 2°C, trifluoroacetic anhydride (5.6 mL, 39.5 mmol) was added dropwise, and the mixture was stirred at about 5°C for 4 hours. To the reaction solution, 17% aqueous acetonitrile (30 mL) was added dropwise, and then water (20 mL) was added dropwise. After the pH was regulated to about 7 with a 25 w/v% aqueous sodium hydroxide solution (33 mL), water (17 mL) was added. Then, the temperature was returned to room temperature, and the precipitated crystals were collected by filtration and washed with water (25 mL) and 75% aqueous acetonitrile (25 mL). The resulting crystals were dried under reduced pressure to give N-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide as pale yellowish white crystals (4.3 g, yield 93%).

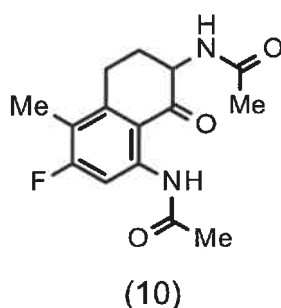
[0306]

(Example 4-1)

N,N'-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide

[0307]

[Chem. 67]



[0308]

A solution of N-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide (5.0 g, 21.3 mmol) in tetrahydrofuran (75 mL) was cooled to 6°C, and amyl nitrite (3.7 mL, 27.6 mmol) and potassium tert-butoxide (2.9 g, 25.5 mmol) were added. After the mixture was stirred at 3°C for 17 hours, acetic acid (25 mL) and acetic anhydride (25 mL) were added, and then the temperature was raised. At about 20°C, a 2% platinum carbon catalyst (1.5 g) was added, and the atmosphere of the mixture was replaced with nitrogen and then replaced with hydrogen. The mixture was stirred at room temperature for 4 hours in a hydrogen stream (0.3 MPa). Insoluble matter was separated by filtration from the resulting suspension, and washed with ethyl acetate (25 mL). Activated carbon (0.7 g) was added to the filtrate, the mixture was stirred at room temperature for 1 hour,

and then insoluble matter was separated by filtration and washed with ethyl acetate (25 mL). The filtrate was cooled to 1°C, and a 5 N aqueous sodium hydroxide solution (50 mL) was added dropwise. The aqueous layer was removed, and a 5 N aqueous sodium hydroxide solution (50 mL) was added again to remove the aqueous layer. After tetrahydrofuran (35 mL) and water (25 mL) were added to the resulting organic layer, a 5 N aqueous sodium hydroxide solution (25 mL) was added to regulate the pH to about 7. After the temperature was raised to room temperature, the aqueous layer was removed, and the organic layer was washed with 10 wt% brine (25 mL). The resulting organic layer was concentrated under reduced pressure to give a concentrated residue. Ethyl acetate (50 mL) was added to the concentrated residue, and the mixture was concentrated under reduced pressure. The concentrated residue (about 25 mL) that had undergone this operation a total of three times was stirred at 40°C for 5 hours, then cooled to room temperature, and stirred at 2°C for 3 hours. The precipitated crystals were collected by filtration and washed with cold ethyl acetate (25 mL) and water (25 mL). The resulting crystals were dried under reduced pressure to give N,N'-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide as white crystals (3.7 g, yield 60%).

[0309]

¹H-NMR (500 MHz, CDCl₃) δ 11.76 (1H, s), 8.43 (1H, d, J=13.0 Hz), 6.53 (1H, d, J=4.5 Hz), 4.62 (1H, dt, J=14.0, 5.4 Hz), 3.08-2.96 (2H, m), 2.78-2.72 (1H, m), 2.23 (3H, s), 2.15 (3H, d, J=1.5 Hz), 2.11 (3H, s), 1.88-1.77 (1H, m)

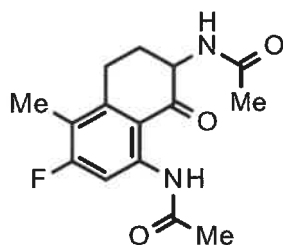
[0310]

(Example 4-2)

N,N'-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide

[0311]

[Chem. 68]



(10)

[0312]

A solution of N-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide (35.0 g, 148.8 mmol) in tetrahydrofuran (525 mL) was cooled to 4°C, and amyl nitrite (25.7 mL, 193.4 mmol) and potassium tert-butoxide (20.0 g, 178.6 mmol) were added. After the mixture was stirred at 1°C for 17 hours, acetic acid (175 mL) and acetic anhydride (175 mL) were added, and then the temperature was raised. At about 20°C, a 2% platinum carbon catalyst (11.8 g) was added, and the atmosphere of

the mixture was replaced with nitrogen and then replaced with hydrogen. The mixture was stirred at room temperature for 3 hours in a hydrogen stream (0.3 MPa). Insoluble matter was separated by filtration from the resulting suspension, and the insoluble matter was washed with ethyl acetate (175 mL). Activated carbon (5.3 g) was added to the filtrate, the mixture was stirred at room temperature for 2 hour, and then insoluble matter was separated by filtration and washed with ethyl acetate (175 mL). The filtrate was cooled to 1°C, and a 5 N aqueous sodium hydroxide solution (350 mL) was added dropwise. The aqueous layer was removed, a 5 N aqueous sodium hydroxide solution (350 mL) was added again to remove the aqueous layer. After tetrahydrofuran (245 mL) and water (175 mL) were added to the resulting organic layer, a 5 N aqueous sodium hydroxide solution (150 mL) was added to regulate the pH to about 7. After the temperature was raised to room temperature, the aqueous layer was removed, and the organic layer was washed with 10 wt% brine (175 mL). The resulting organic layer was concentrated under reduced pressure to give a concentrated residue. Ethyl acetate (350 mL) was added to the concentrated residue, and the mixture was concentrated under reduced pressure. The concentrated residue (about 175 mL) that had undergone this operation a total of three times was stirred at 40°C for 5 hours, then cooled to room temperature, and stirred at 2°C for 3

hours. The precipitated crystals were collected by filtration and washed with cold ethyl acetate (175 mL) and water (175 mL). The resulting crystals were dried under reduced pressure to obtain white crystals (25.1 g).

A suspension of the obtained crystals (24.0 g, 82.1 mmol) in 20% aqueous ethanol (300 mL) was heated to 65°C. Activated carbon (4.8 g) was added, the mixture was stirred for 30 minutes at 70°C, then insoluble matter was separated by filtration and washed with 20% aqueous ethanol (72 mL). After water (300 mL) at 60°C was added dropwise to the filtrate, the mixture was annealed to 2°C and stirred for 2 hours. The precipitated crystals were collected by filtration and washed with cold 60% aqueous ethanol (120 mL). The resulting crystals were dried under reduced pressure to give N,N'-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide as white crystals (21.6 g, yield 52%).

[0313]

¹H-NMR (500 MHz, CDCl₃) δ 11.76 (1H, s), 8.43 (1H, d, J=13.0 Hz), 6.53 (1H, d, J=4.5 Hz), 4.62 (1H, dt, J=14.0, 5.4 Hz), 3.08-2.96 (2H, m), 2.78-2.72 (1H, m), 2.23 (3H, s), 2.15 (3H, d, J=1.5 Hz), 2.11 (3H, s), 1.88-1.77 (1H, m)

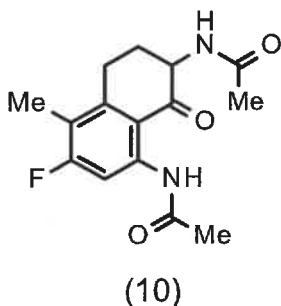
[0314]

(Example 4-3)

N,N'-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide

[0315]

[Chem. 69]



[0316]

A solution of N-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide (3.0 g, 12.8 mmol) in tetrahydrofuran (45 mL) was cooled to 0°C, and amyl nitrite (2.2 mL, 16.6 mmol) and potassium tert-butoxide (1.7 g, 15.3 mmol) were added. After the mixture was stirred at 3°C for 3 hours, acetic acid (15 mL) and acetic anhydride (15 mL) were added, the temperature was raised to 20°C, and the mixture was stirred for 1.5 hours. At about 3°C, a 5% platinum carbon catalyst (0.4 g) was added, and the atmosphere of the mixture was replaced with nitrogen and then replaced with hydrogen. The mixture was stirred at about 5°C for 3 hours in a hydrogen stream (0.6 MPa). Then, the mixture was stirred at about 30°C for 1 hour, and insoluble matter was separated by filtration, and the insoluble matter was washed with ethyl acetate (15 mL). Activated carbon (0.5 g) was added to the filtrate, the mixture was stirred at room temperature for 2 hours, and then insoluble matter

was separated by filtration and washed with ethyl acetate (15 mL). The filtrate was cooled to about 5°C, and a 5 N aqueous sodium hydroxide solution (30 mL) was added dropwise. The aqueous layer was removed, tetrahydrofuran (30 mL) and a 5 N aqueous sodium hydroxide solution (30 mL) were added to remove the aqueous layer. After water (15 mL) was added to the resulting organic layer, a 5 N aqueous sodium hydroxide solution (15 mL) was added to regulate the pH to about 7. After the temperature was raised to room temperature, the aqueous layer was removed, and the organic layer was washed with 10 wt% brine (15 mL). The resulting organic layer was concentrated under reduced pressure to give a concentrated residue. Ethyl acetate (30 mL) was added to the concentrated residue, and the mixture was concentrated under reduced pressure. The concentrated residue (about 15 mL) that had undergone this operation a total of three times was stirred at 40°C for 5 hours, cooled to room temperature, and stirred at 5°C for 2 hours or longer. The precipitated crystals were collected by filtration and washed with cold ethyl acetate (15 mL) and water (15 mL). The resulting crystals were dried under reduced pressure to give N,N'-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide as white crystals (2.3 g, yield 62%).

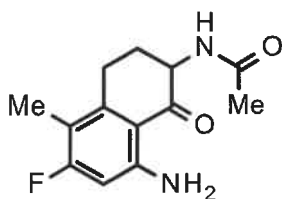
[0317]

(Example 5-1)

N-(8-Amino-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)acetamide

[0318]

[Chem. 70]



(11)

[0319]

A suspension of N,N'-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide (3.0 g, 10.3 mmol) in 2N hydrochloric acid/ethanol (30 mL) was stirred at 50°C for 7 hours. Water (45 mL) was added to the resulting reaction solution, and the mixture was cooled to 1°C. After triethylamine (8.6 mL, 61.6 mmol) at 1°C was added dropwise, sodium sulfite (26 mg, 0.2 mmol) was added. After the mixture was stirred at 1°C for 4 hours, the precipitated crystals were collected by filtration and washed with cold 60% aqueous ethanol (30 mL) and water (15 mL). The resulting crystals were dried under reduced pressure to obtain pale green crystals (2.4 g). A suspension of the obtained pale green crystals (1.8 g) in acetone (18 mL) was stirred at 50°C for 5 hours and then cooled to room temperature. The precipitated crystals were collected by filtration and washed with acetone (9 mL). The resulting crystals were

dried at 40°C under reduced pressure to give N-(8-amino-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)acetamide as pale green crystals (1.6 g, yield 82%).

[0320]

¹H-NMR (400 MHz, DMSO-d₆) δ 8.07 (1H, d, J=8.0 Hz), 7.40 (2H, brs), 6.38 (1H, d, J=13.2 Hz), 4.52-4.43 (1H, m), 2.98-2.88 (1H, m), 2.87-2.76 (1H, m), 2.18-2.10 (1H, m), 1.98 (3H, d, J=1.2 Hz), 1.90 (3H, s), 1.88-1.78 (1H, m)

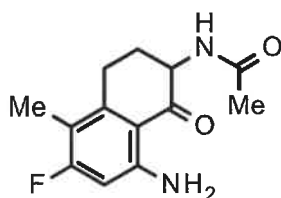
[0321]

(Example 5-2)

N-(8-Amino-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)acetamide

[0322]

[Chem. 71]



(11)

[0323]

N,N'-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1,7-diyl)diacetamide (5.0 g, 17.1 mmol) was added in 5 divided portions to 2N hydrochloric acid/ethanol (75 mL) at room temperature, and the mixture was stirred at 50°C for 5 hours. Water (113 mL) was added to the resulting reaction solution, and the mixture was cooled to 2°C. After triethylamine (22.5 mL, 161.4

mmol) was added dropwise at 2°C, sodium sulfite (43 mg, 0.3 mmol) was added. After the mixture was stirred at 2°C for 3 hours, the precipitated crystals were collected by filtration and washed with cold 60% aqueous ethanol (50 mL) and water (25 mL). The resulting crystals were dried under reduced pressure to obtain pale blue crystals (3.9 g). A suspension of the obtained crystals (1.8 g) in acetone (18 mL) was stirred at 50°C for 5 hours and then cooled to room temperature. The precipitated crystals were collected by filtration and washed with acetone (9 mL). The resulting crystals were dried at 40°C under reduced pressure to give N-(8-amino-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)acetamide as pale green crystals (1.6 g, yield 80%).

[0324]

¹H-NMR (400 MHz, DMSO-d₆) δ 8.07 (1H, d, J=8.0 Hz), 7.40 (2H, brs), 6.38 (1H, d, J=13.2 Hz), 4.52-4.43 (1H, m), 2.98-2.88 (1H, m), 2.87-2.76 (1H, m), 2.18-2.10 (1H, m), 1.98 (3H, d, J=1.2 Hz), 1.90 (3H, s), 1.88-1.78 (1H, m)

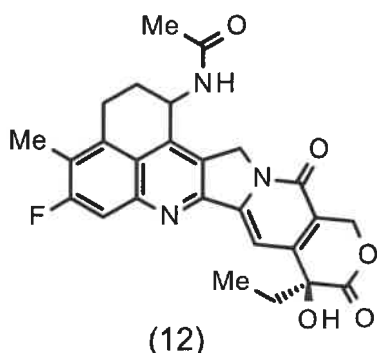
[0325]

(Example 6-1)

N-[(9S)-9-Ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-yl]acetamide

[0326]

[Chem. 72]



[0327]

o-Cresol (510 mL) and pyridinium p-toluenesulfonate (25.6 g, 102 mmol) were added to a suspension of N-(8-amino-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)acetamide (170.0 g, 679 mmol) and (4S)-4-ethyl-4-hydroxy-7,8-dihydro-1H-pyrano[3,4-f]indolizin-3,6,10(4H)-trione (196.7 g, 747 mmol) in toluene (8.5 L), and the mixture was refluxed for 32 hours. Toluene (500 mL) was added, and the mixture was cooled to room temperature and stirred for 2 more hours. The precipitated crystals were filtered, and the crystals separated by filtration were washed with acetone (850 mL). The resulting crystals were dried at 40°C under reduced pressure to give yellow crystals of N-[(9S)-9-ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-yl]acetamide (312.5 g, yield 96%).

[0328]

¹H-NMR (400 MHz, DMSO-d₆) δ 0.87 (3H, t, J=7.3 Hz), 1.79-1.88 (2H, m), 1.91 (3H, s), 2.13-2.15 (2H, m), 2.39 (3H,

s), 3.13-3.22 (2H, m), 5.20 (2H, dd, J=25.6, 18.9 Hz), 5.42 (2H, s), 5.53-5.57 (1H, m), 6.52 (1H, s), 6.65-6.69 (0.4H, m), 6.75 (0.4H, d, J=7.9 Hz), 6.95-6.99 (0.4H, m), 7.03 (0.4H, d, J=7.3 Hz), 7.13-7.27 (0.4H, m). 7.30 (1H, s), 7.79 (1H, d, J=11.0 Hz), 8.46 (1H, d, J=9.2 Hz), 9.19 (0.4H, s).

¹³C-NMR (100 MHz, DMSO-d₆) δ 7.7, 10.9, 10.9, 15.9, 22.6, 23.1, 27.7, 30.3, 44.0, 49.5, 65.2, 72.3, 96.6, 109.7, 109.9, 114.5, 118.7, 119.1, 121.4, 123.6, 123.7, 123.7, 125.3, 125.5, 126.6, 128.2, 128.9, 130.5, 136.2, 136.3, 140.4, 145.2, 147.8, 147.9, 149.9, 152.3, 155.3, 156.6, 160.3, 162.8, 169.1, 172.4.

MS (ESI) (m/z): 478 ([M+H]⁺).

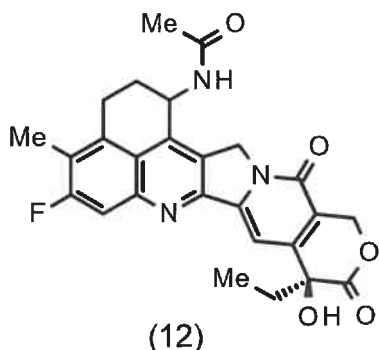
[0329]

(Example 6-2)

N-[(9S)-9-Ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-yl]acetamide

[0330]

[Chem. 73]



[0331]

o-Cresol (7.5 mL) and pyridinium p-toluenesulfonate (0.75 g, 3.00 mmol) were added to a suspension of N-(8-amino-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)acetamide (2.5 g, 9.99 mmol) and (4S)-4-ethyl-4-hydroxy-7,8-dihydro-1H-pyrano[3,4-f]indolizin-3,6,10(4H)-trione (3.42 g, 12.99 mmol) in toluene (125 mL), and the mixture was refluxed for 19 hours (it was confirmed that this step proceeded via a compound represented by formula (30) and a compound represented by formula (31) as reaction intermediates).

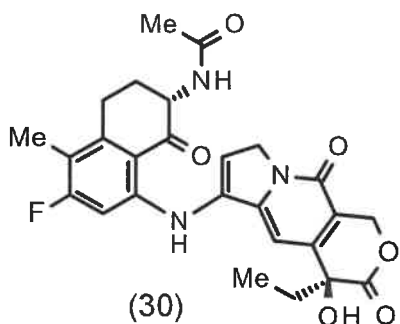
[0332]

Compound represented by formula (30):

N-[(2S)-8-{[(4S)-4-Ethyl-4-hydroxy-3,10-dioxo-3,4,8,10-tetrahydro-1H-pyrano[3,4-f]indolizin-6-yl]amino}-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl]acetamide

[0333]

[Chem. 74]



[0334]

^1H -NMR (500 MHz, CDCl_3) δ 1.04 (3H, t, $J=7.5$ Hz), 1.80-1.93 (2H, m), 2.02-2.18 (8H, m), 3.80-3.85 (1H, m), 4.62-4.68 (1H, m), 4.75-4.85 (m, 2H), 5.20-5.33 (m, 2H), 5.70 (1H, d, $J=16.0$ Hz), 6.35 (1H, s), 6.67 (1H, d, $J=5.5$ Hz), 6.88 (1H, s), 6.99 (1H, d, $J=12.0$ Hz), 11.14 (1H, s).

MS (ESI) (m/z): 496.5 ($[\text{M}+\text{H}]^+$).

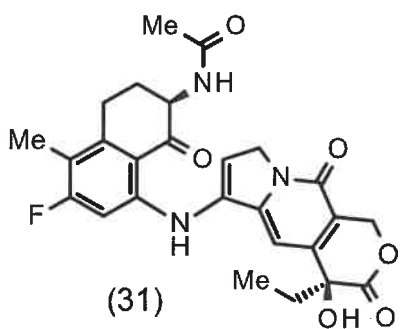
[0335]

Compound represented by formula (31):

N-[(2R)-8-{[(4S)-4-Ethyl-4-hydroxy-3,10-dioxo-3,4,8,10-tetrahydro-1H-pyrano[3,4-f]indolizin-6-yl]amino}-6-fluoro-5-methyl-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl]acetamide

[0336]

[Chem. 75]



[0337]

^1H -NMR (500 MHz, CDCl_3) δ 1.03 (3H, t, $J=7.5$ Hz), 1.80-1.92 (2H, m), 2.02-2.18 (8H, m), 3.79 (1H, s), 4.60-4.68 (1H, m), 4.72-4.87 (m, 2H), 5.28 (1H, d, $J=16.0$ Hz), 5.70 (1H, d, $J=16.0$ Hz), 6.35 (1H, s), 6.68 (1H, d, $J=4.5$ Hz), 6.88 (1H, s), 7.00 (1H, d, $J=12.0$ Hz), 11.10 (1H, s).

MS (ESI) (m/z): 496.6 ($[\text{M}+\text{H}]^+$).

[0338]

After cooling, the liquid volume was regulated to 135 mL with toluene, and the mixture was stirred for 2 more hours. The precipitated crystals were filtered, and the crystals separated by filtration were washed with acetone (12.5 mL). The resulting crystals were dried at 40°C under reduced pressure to give yellow crystals of N-[(9S)-9-ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-yl]acetamide (4.58 g, yield 96%).

[0339]

The apparatus data was the same as that of the compound described in Example 6-1.

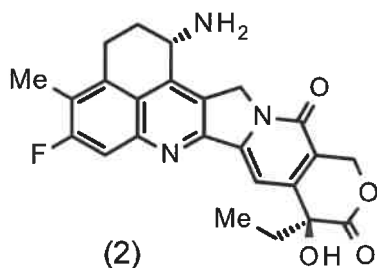
[0340]

(Example 7-1)

(1S,9S)-9-Ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-aminium methanesulfonate dihydrate

[0341]

[Chem. 76]



[0342]

Methanesulfonic acid (1.5 L) was added to a suspension of N-[(9S)-9-ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-yl]acetamide (300.0 g, 628 mmol) in 2-methoxyethanol (1.5 L), water (4.5 L), and ethylcyclohexane (1.5 L), and the mixture was refluxed for 8 hours. After the mixture was cooled to room temperature and separated to remove the organic layer, the removed organic layer was concentrated to 3 L under reduced pressure. The concentrate was heated to 40°C, and methanol (6 L) was added dropwise over 30 minutes. After the mixture was stirred for 2 hours, the precipitated crystals were filtered, and the crystals separated by filtration were washed with methanol (1.5 L).

[0343]

The resulting crystals were dissolved in water (1.2 L), methanol (600 mL), and methanesulfonic acid (1.2 L), activated carbon (15 g) was added, and the mixture was stirred for 30 minutes. After cellulose powder (150 g) was added, and the mixture was stirred for 30 minutes, insoluble matter was separated by filtration and washed with a 50% methanesulfonic acid solution (600 mL) and methanol (600 mL). The filtrate was heated to 40°C, and methanol (4.8 L) was added dropwise over 55 minutes. After the mixture was stirred for 2 hours, the

precipitated crystals were filtered, and the crystals separated by filtration were washed with methanol (1.5 L). [0344]

The resulting crystals were suspended in ethanol (6 L) and water (600 mL), and the mixture was refluxed for 1.5 hours. After the mixture was cooled to room temperature and stirred for 30 minutes, the precipitated crystals were filtered and washed with ethanol (1.5 L). The resulting crystals were dried at 40°C under reduced pressure and then humidified for 4 days in air having 40% RH to give colorless crystals of (1S,9S)-9-ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-aminium methanesulfonate dihydrate (152.3 g, yield 43%). [0345]

¹H-NMR (400 MHz, DMSO-d₆, D₂O) δ 0.89 (3H, t, J=7.3 Hz), 1.90 (2H, q, J=7.3 Hz), 2.35 (3H, s), 2.38-2.47 (1H, m), 2.64 (3H, s), 3.04-3.11 (1H, m), 3.30-3.34 (1H, m), 5.08 (1H, s), 5.34 (2H, dd, J=17.7, 15.9 Hz), 5.50 (2H, dd, J=17.7, 10.4 Hz), 7.41 (1H, s), 7.59 (1H, d, J=11.0 Hz).
¹³C-NMR (125 MHz, DMSO-d₆) δ 7.7, 10.9, 11.0, 18.5, 20.8, 24.7, 30.2, 39.5, 44.5, 49.4, 55.9, 65.2, 72.2, 95.3, 96.9, 110.1, 100.3, 119.4, 120.5, 124.6, 124.7, 127.5, 134.2, 135.2, 135.2, 144.8, 147.8, 147.9, 149.9, 152.3, 156.6, 160.6, 162.6, 172.3.
MS (ESI) (m/z): 436 ([M+H]⁺).

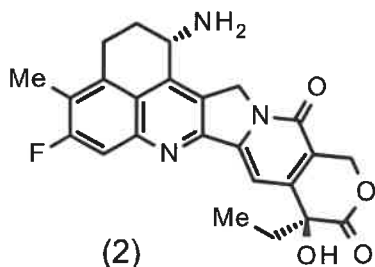
[0346]

(Example 7-2)

(1S,9S)-9-Ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-
2,3,9,10,13,15-hexahydro-1H,12H-
benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-
aminium methanesulfonate

[0347]

[Chem. 77]



[0348]

Methanesulfonic acid (18 mL) was added to a suspension of N-[(9S)-9-ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-yl]acetamide (3.5 g, 7.3 mmol) in purified water (53 mL), 2-methoxyethanol (18 mL), and ethylcyclohexane (18 mL), and then the atmosphere of the mixture was repeatedly replaced with nitrogen under reduced pressure 3 times (the operation of performing stirring under reduced pressure at 50 mbar and then nitrogen replacement under normal pressure was repeated 3 times). The suspension was heated to 85°C and then stirred for 11 hours, and cooled to 25°C after confirming the completion of the

reaction. The mixture was concentrated under reduced pressure to 38.5 mL, the concentrate was heated to 40°C, and methanol (18 mL) was added dropwise over 15 minutes. After the mixture was stirred for 6 hours, methanol (53 mL) was added dropwise over 2 hours, and after the mixture was stirred for 2 more hours, the precipitated crystals were filtered, and the crystals separated by filtration were washed with methanol (35 mL).

[0349]

The resulting crystals were dissolved in a mixed solution of purified water (14 mL) and methanesulfonic acid (14 mL), the mixture was heated to 37°C, then methanol (7 mL), activated carbon (0.35 g), and a filter aid (0.70 g, diatomaceous earth: Celpure C 1000) were added, and nitrogen replacement of the atmosphere under reduced pressure was repeated 3 times (3 times of 50 mbar and normal-pressure nitrogen replacement). After the suspension was stirred for 20 minutes, insoluble matter was separated by filtration and washed with a mixed solution of methanesulfonic acid, purified water, and methanol (7 mL, 7 mL, 3.5 mL) and methanol (7 mL). The filtrate was heated to 37°C, and methanol (10.5 mL) was added dropwise over 15 minutes. After the mixture was stirred for 6 hours, methanol (42 mL) was added dropwise over 1 hour, and after the mixture was stirred for 2 more hours, the precipitated crystals were filtered, and the

crystals separated by filtration were washed with methanol (35 mL).

[0350]

The resulting crystals were suspended in ethanol (70 mL) and water (7 mL) and stirred at 73°C for 2 hours. After the suspension was cooled to 25°C and stirred for 2 hours, the precipitated crystals were filtered and washed with ethanol (18 mL). The resulting crystals were dried at 40°C under reduced pressure to give (1S,9S)-9-ethyl-5-fluoro-9-hydroxy-4-methyl-10,13-dioxo-2,3,9,10,13,15-hexahydro-1H,12H-benzo[de]pyrano[3',4':6,7]indolizino[1,2-b]quinolin-1-aminium methanesulfonate (1.72 g, yield 44%).

[0351]

The apparatus data was the same as that of the compound described in Example 7-1.

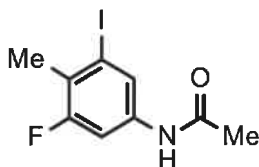
[0352]

(Example 8)

N-(3-Iodo-5-fluoro-4-methylphenyl)acetamide

[0353]

[Chem. 78]



(34)

[0354]

A solution of 2-fluoro-1-methyl-4-nitrobenzene (5.0 g, 32.3 mmol) in concentrated sulfuric acid (90% or more, 25 mL) and heptane (25 mL) was cooled to about 1°C, and then N-iodosuccinimide (10.2 g, 45.1 mmol) was added in six divided portions. The mixture was stirred at about 2°C for 2 hours. The resulting reaction solution was added to cold water (25 mL). After toluene (25 mL) was added for separation, the aqueous layer was removed. Then, the organic layer was washed with water (25 mL), a 6.5 wt% aqueous sodium hydrogencarbonate solution (25 mL), a 5 wt% aqueous sodium sulfite solution (25 mL, 3 times), and finally water (25 mL). After the aqueous layer was removed from the filtrate, the organic layer was concentrated under reduced pressure. Ethyl acetate (50 mL) was added to the concentrated residue (about 30 mL), and the mixture was concentrated again under reduced pressure to give a solution of 1-iodo-3-fluoro-2-methyl-5-nitrobenzene in ethyl acetate (about 15 mL).

[0355]

A suspension was obtained by adding a 1% platinum carbon catalyst (1.1 g) and ethyl acetate (45 mL) to the solution of 1-iodo-3-fluoro-2-methyl-5-nitrobenzene in ethyl acetate (about 15 mL) and the atmosphere was replaced with nitrogen and then replaced with hydrogen. The suspension was stirred at about 60°C for 5 hours in a hydrogen stream (0.1 MPa) and cooled to room temperature. Insoluble matter was separated by filtration from the

resulting suspension and washed with ethyl acetate (15 mL). The filtrate was washed twice with a 0.5N hydrochloric acid solution (50 mL, 25 mL) to obtain an organic layer. The aqueous layer at this time was extracted with ethyl acetate (25 mL) to obtain an organic layer, and the organic layers were combined. Then, the organic layer was washed with a 6.5 wt% aqueous sodium hydrogencarbonate solution (25 mL) and 5 wt% brine (25 mL), and the resulting organic layer was concentrated under reduced pressure to give a solution of 3-iodo-5-fluoro-4-methylaniline in ethyl acetate.

[0356]

Triethylamine (3.7 mL, 26.8 mmol) and acetic anhydride (1.7 mL, 17.7 mmol) were added to a solution obtained by adding ethyl acetate (25 mL) to the solution of 3-bromo-5-fluoro-4-methylaniline in ethyl acetate (25 mL), and the mixture was stirred at room temperature for 4 hours. After 10 wt% brine (25 mL) was added to the resulting reaction solution for separation, the aqueous layer was removed. The resulting organic layer was concentrated under reduced pressure. Ethyl acetate (50 mL) was added to the concentrated residue, a 4N hydrochloric acid/ethyl acetate solution (5.6 mL, 22.6 mmol) was added, and then the mixture was stirred at room temperature for 15 minutes. Insoluble matter was separated by filtration and washed with ethyl acetate (20 mL). After 10 wt% brine (20 mL) was added to the

filtrate, a 25 w/v% aqueous sodium hydroxide solution (2.5 mL) was added to regulate the pH to about 7. After the aqueous layer was removed, the organic layer was concentrated under reduced pressure. Acetonitrile (38 mL) and water (38 mL) were added to the concentrated residue, and the concentrated residue was stirred at 25°C. The precipitated crystals were collected by filtration and washed with 50% aqueous acetonitrile (15 mL). The resulting crystals were dried at 40°C under reduced pressure to give N-(3-iodo-5-fluoro-4-methylphenyl)acetamide as white crystals (2.8 g, yield 29%).

[0357]

¹H-NMR (500 MHz, CDCl₃) δ 7.61 (1H, s), 7.47 (1H, d, J=10.8 Hz), 7.10 (1H, brs), 2.30 (3H, d, J=2.3 Hz), 2.16 (3H, s)

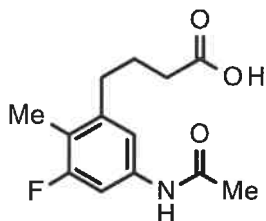
[0358]

(Example 9)

4-[5-(Acetylamino)-3-fluoro-2-methylphenyl]butanoic acid

[0359]

[Chem. 79]



(8)

[0360]

A solution of N-(3-iodo-5-fluoro-4-methylphenyl)acetamide (2.0 g, 6.8 mmol), 3-butenic acid (0.7 mL, 8.2 mmol), and diisopropylethylamine (2.6 mL, 15.0 mmol) in tetrahydrofuran (8 mL) and water (2 mL) was degassed under reduced pressure and the atmosphere was replaced with nitrogen, and then tri(o-tolyl)phosphine (62.3 mg, 0.2 mmol) was added. Again the mixture was degassed under reduced pressure and the atmosphere was replaced with nitrogen, then palladium(II) acetate (23.0 mg, 0.1 mmol) was added, and the mixture was degassed under reduced pressure, the atmosphere replaced with nitrogen, and then thermally refluxed for 2 hours. Activated carbon (0.2 g), 2-methyltetrahydrofuran (10 mL), and water (10 mL) were added to the reaction solution that had been cooled to room temperature, and the mixture was stirred at room temperature for 1 hour. Insoluble matter was separated by filtration and washed with 20% aqueous tetrahydrofuran (4 mL). 2-Methyltetrahydrofuran (10 mL) and water (10 mL) were added to the filtrate, and a 25 w/v% aqueous sodium hydroxide solution (1.3 mL, 8.2 mmol) was added. The organic layer was removed, 2-methyltetrahydrofuran (20 mL) and concentrated hydrochloric acid (36%, 1.2 g, 12.3 mmol) were added to the aqueous layer, and then sodium chloride (2 g) was added. After separation, the aqueous layer was removed, and the organic layer was washed with 10 wt% brine (6 mL). The resulting organic layer was concentrated under

reduced pressure to give 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]-3-butenic acid residue containing geometric isomers (1.9 g).

[0361]

A suspension was obtained by adding 2-methyltetrahydrofuran (30 mL) and 5% palladium carbon (1.7 g) to the 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]-3-butenic acid residue containing geometric isomers (1.9 g) and the atmosphere was replaced with nitrogen, and then replaced with hydrogen. The mixture was stirred at about 40°C for 8 hours in a hydrogen stream (0.3 MPa) and cooled to room temperature. Insoluble matter was separated by filtration from the resulting suspension and washed with 2-methyltetrahydrofuran (8 mL). Water (10 mL) was added to the filtrate, and the pH was regulated to about 2 with a 1N hydrochloric acid solution. After separation, the aqueous layer was removed, and the resulting organic layer was concentrated under reduced pressure. Ethyl acetate (10 mL) was added to the concentrated residue, the mixture was heated to about 50°C, then heptane (10 mL) was added, and the mixture was cooled to room temperature. The precipitated crystals were collected by filtration and washed with ethyl acetate/heptane (3/7) (6 mL). The resulting crystals were dried under reduced pressure to give 4-[5-(acetylamino)-3-fluoro-2-

methylphenyl]butanoic acid as white crystals (1.4 g, yield 81%).

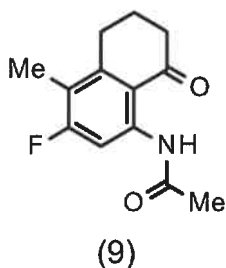
[0362]

(Example 10)

N-(3-Fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide

[0363]

[Chem. 80]



[0364]

Aluminium chloride (263 mg, 1.97 mmol) was added to a solution of 4-[5-(acetylamino)-3-fluoro-2-methylphenyl]butanoic acid (200 mg, 0.79 mmol), thionyl chloride (86 μ L, 1.18 mmol), and methylene chloride (4 mL) at room temperature under a nitrogen stream, and the mixture was stirred at room temperature for 2 hours. A 1N aqueous hydrochloric acid solution (10 mL) and ethyl acetate (50 mL) were added to the resulting reaction solution. The aqueous layer was removed, the organic layer was washed with water (10 mL), a 6.5 wt% aqueous sodium hydrogencarbonate solution (10 mL), and water (10 mL), and the resulting organic layer was dried over sodium sulfate. Insoluble matter was separated by

filtration, the solvent was distilled off under reduced pressure, and the resulting residue was purified by preparative thin layer chromatography (hexane:ethyl acetate = 2:1) to give N-(3-fluoro-4-methyl-8-oxo-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide as pale yellowish white crystals (125 mg, yield 67%).

[0365]

The apparatus data was the same as that of the compound described in Example 3-1.

Free Text of Sequence Listing

[0366]

SEQ ID NO: 1 - Amino acid sequence of a heavy chain of the anti-HER2 antibody

SEQ ID NO: 2 - Amino acid sequence of a light chain of the anti-HER2 antibody

SEQ ID NO: 3 - Amino acid sequence of a heavy chain of the anti-HER3 antibody

SEQ ID NO: 4 - Amino acid sequence of a light chain of the anti-HER3 antibody

SEQ ID NO: 5 - Amino acid sequence of a heavy chain of the anti-TROP2 antibody

SEQ ID NO: 6 - Amino acid sequence of a light chain of the anti-TROP2 antibody

SEQ ID NO: 7 - Amino acid sequence of a heavy chain of the anti-B7-H3 antibody

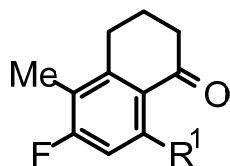
SEQ ID NO: 8 - Amino acid sequence of a light chain of the anti-B7-H3 antibody

SEQ ID NO: 9 - Amino acid sequence of a heavy chain of the anti-GPR20 antibody

SEQ ID NO: 10 - Amino acid sequence of a light chain of the anti-GPR20 antibody

Claims

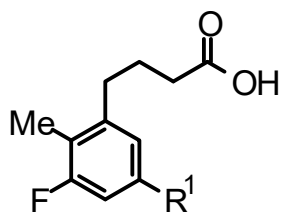
1. A method for producing a compound represented by formula (C):



(C)

wherein R¹ represents an amino group protected with a protecting group,

the method comprising a step of subjecting a compound represented by formula (B):

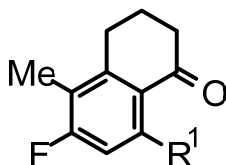


(B)

wherein R¹ represents the same meaning as above, to intramolecular cyclization to convert the compound represented by formula (B) into the compound represented by formula (C).

2. The production method according to claim 1, wherein R¹ is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

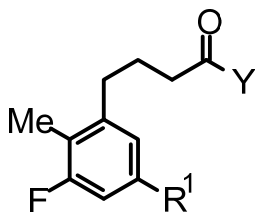
3. The production method according to claim 1, wherein R^1 is an amino group protected with an acetyl group or a trifluoroacetyl group.
4. The production method according to claim 1, wherein R^1 is an amino group protected with an acetyl group.
5. The production method according to any one of claims 1 to 4, wherein the intramolecular cyclization is performed by a method comprising reacting the compound represented by formula (B) with trifluoroacetic anhydride.
6. The production method according to claim 5, wherein the intramolecular cyclization is performed in a solvent comprising trifluoroacetic acid.
7. The production method according to any one of claims 1 to 4, wherein the intramolecular cyclization is performed by a method comprising reacting the compound represented by formula (B) with thionyl chloride.
8. The production method according to claim 7, wherein the intramolecular cyclization is performed in the presence of aluminium chloride.
9. A method for producing a compound represented by formula (C):



(C)

wherein R^1 represents an amino group protected with a protecting group,

the method comprising a step of subjecting a compound represented by formula (J):



(J)

wherein Y represents a leaving group, and R^1 represents the same meaning as above, to intramolecular cyclization to convert the compound represented by formula (J) into the compound represented by formula (C).

10. The production method according to claim 9, wherein R^1 is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

11. The production method according to claim 9, wherein R^1 is an amino group protected with an acetyl group or a trifluoroacetyl group.

12. The production method according to claim 9, wherein R^1 is an amino group protected with an acetyl group.

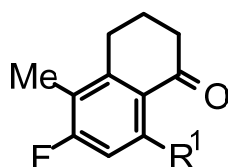
13. The production method according to any one of claims 9 to 12, wherein Y is a chloro group.

14. The production method according to any one of claims 9 to 12, wherein Y is a trifluoroacetoxy group.

15. The production method according to claim 13, wherein the intramolecular cyclization is performed in the presence of aluminium chloride.

16. The production method according to claim 14, wherein the intramolecular cyclization is performed in a solvent comprising trifluoroacetic acid.

17. A method for producing a compound represented by formula (C):

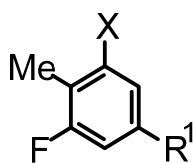


(C)

wherein R¹ represents an amino group protected with a protecting group,

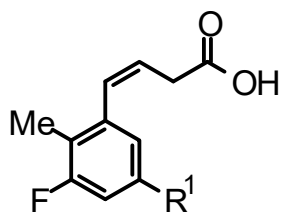
the method comprising the steps of:

coupling a compound represented by formula (D):



(D)

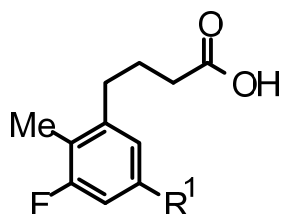
wherein X represents a leaving group, and R¹ represents the same meaning as above, with 3-butenic acid to convert the compound represented by formula (D) into a compound represented by formula (E):



(E)

wherein R¹ represents the same meaning as above; then

reducing the compound represented by formula (E) to convert the compound represented by formula (E) into a compound represented by formula (B):



(B)

wherein R¹ represents the same meaning as above; and then

subjecting the compound represented by formula (B) to intramolecular cyclization to convert the compound represented by formula (B) into the compound represented by formula (C).

18. The production method according to claim 17, wherein X is a bromo group, an iodo group, a trifluoromethanesulfonyloxy group, or an arylsulfonyloxy group.

19. The production method according to claim 17, wherein X is a bromo group.

20. The production method according to claim 17, wherein X is an iodo group.

21. The production method according to any one of claims 17 to 20, wherein R¹ is an amino group protected with an acetyl group, a methoxyacetyl group, a trifluoroacetyl group, a trichloroacetyl group, a pivaloyl group, a formyl group, or a benzoyl group.

22. The production method according to any one of claims 17 to 20, wherein R¹ is an amino group protected with an acetyl group or a trifluoroacetyl group.

23. The production method according to any one of claims 17 to 20, wherein R¹ is an amino group protected with an acetyl group.

24. The production method according to any one of claims 17 to 23, wherein the step of coupling the compound represented by formula (D) with 3-butenic acid to convert the compound represented by formula (D) into the compound represented by formula (E) is performed in the presence of a palladium complex prepared from palladium(II) acetate and tri(o-tolyl)phosphine.

25. The production method according to any one of claims 17 to 24, comprising the steps of: dissolving the compound represented by formula (E) in a basic aqueous solution to wash the compound represented by formula (E) with a first organic solvent and separating the solvents; and then adding an acid to the basic aqueous solution to extract the compound represented by formula (E) with a second organic solvent and separating the solvents.

26. The production method according to claim 25, wherein the first organic solvent is 2-methyltetrahydrofuran.

27. The production method according to claim 25 or 26, wherein the second organic solvent is 2-methyltetrahydrofuran.

28. The production method according to any one of claims 25 to 27, wherein the basic aqueous solution is an aqueous sodium hydroxide solution.

29. The production method according to any one of claims 17 to 28, wherein the step of reducing the compound represented by formula (E) to convert the compound represented by formula (E) into the compound represented by formula (B) is performed by a method comprising reacting the compound represented by formula (E) with hydrogen in a solvent in the presence of a palladium carbon catalyst.

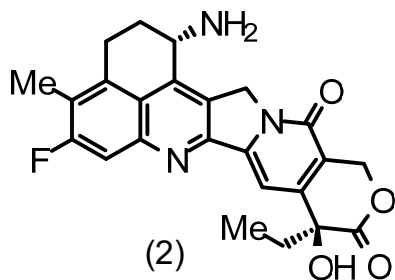
30. The production method according to any one of claims 17 to 29, wherein the step of subjecting the compound represented by formula (B) to intramolecular cyclization to convert the compound represented by formula (B) into the compound represented by formula (C) is performed by a method comprising reacting the compound represented by formula (B) with trifluoroacetic anhydride.

31. The production method according to claim 30, wherein the intramolecular cyclization is performed in a solvent comprising trifluoroacetic acid.

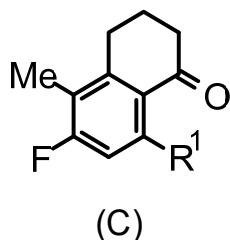
32. The production method according to any one of claims 17 to 29, wherein the step of subjecting the compound represented by formula (B) to intramolecular cyclization to convert the compound represented by formula (B) into the compound represented by formula (C) is performed by a method comprising reacting the compound represented by formula (B) with thionyl chloride.

33. The production method according to claim 32, wherein the intramolecular cyclization is performed in the presence of aluminium chloride.

34. A method for producing a compound represented by formula (2):



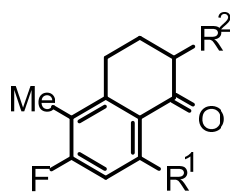
wherein a compound represented by formula (C):



produced by the method according to any one of claims 1 to 33 is used as a starting material, the method comprising the steps of:

converting the compound represented by formula (C) into a compound represented by formula (F):

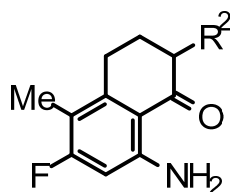
-162-



(F)

wherein R^1 represents the same meaning as defined in any one of claims 1 to 33, and R^2 represents an amino group protected with a protecting group; then

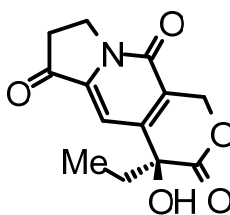
converting the compound represented by formula (F) into a compound represented by formula (G):



(G)

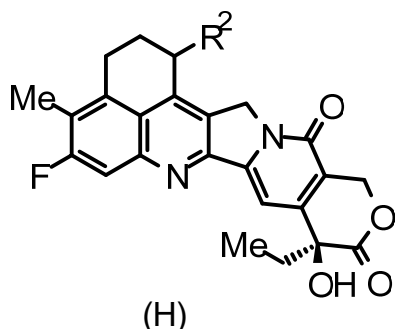
wherein R^2 represents the same meaning as above; then

condensing the compound represented by formula (G) with a compound represented by formula (1):



(1)

to convert the compound represented by formula (G) into a compound represented by formula (H):



wherein R^2 represents the same meaning as above; and then
 converting the compound represented by formula (H)
 into the compound represented by formula (2).

35. The production method according to claim 34, wherein
 R^2 is an amino group protected with an acetyl group, a
 methoxyacetyl group, a trifluoroacetyl group, a
 trichloroacetyl group, a pivaloyl group, a formyl group,
 or a benzoyl group.

36. The production method according to claim 34, wherein
 R^2 is an amino group protected with an acetyl group or a
 trifluoroacetyl group.

37. The production method according to claim 34, wherein
 R^2 is an amino group protected with an acetyl group.

38. The production method according to any one of claims
 34 to 37, wherein the step of converting the compound
 represented by formula (C) into the compound represented
 by formula (F) comprises the sub-steps of: (i) reacting
 the compound represented by formula (C) with a nitrous
 acid ester in the presence of a base to introduce a
 nitroso group; (ii) introducing a protecting group to a
 nitrogen atom derived from the nitroso group; and (iii)

reducing the compound represented by formula (C) with hydrogen in the presence of a platinum carbon catalyst.

39. The production method according to any one of claims 34 to 38, wherein the step of converting the compound represented by formula (F) into the compound represented by formula (G) is performed in a solvent comprising hydrochloric acid/ethanol.

40. The production method according to any one of claims 34 to 39, wherein the step of condensing the compound represented by formula (G) with the compound represented by formula (1) to convert the compound represented by formula (G) into the compound represented by formula (H) is performed in a solvent comprising o-cresol.

41. The production method according to any one of claims 34 to 40, wherein the step of converting the compound represented by formula (H) into the compound represented by formula (2) is performed in a solvent comprising methanesulfonic acid.

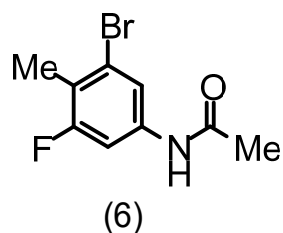
42. The production method according to any one of claims 34 to 41, wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt.

43. The production method according to any one of claims 34 to 41, wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt m-hydrate wherein m is in a range of 0 to 3.

44. The production method according to any one of claims 34 to 41, wherein the compound represented by formula (2) is in the form of a methanesulfonic acid salt dihydrate.

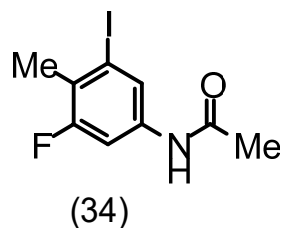
45. The production method according to any one of claims 1 to 44, wherein no chromatography is used.

46. A compound represented by formula (6):



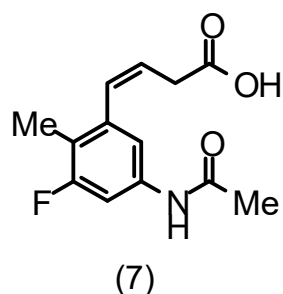
.

47. A compound represented by formula (34):



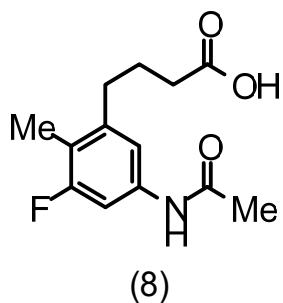
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48. A compound represented by formula (7):

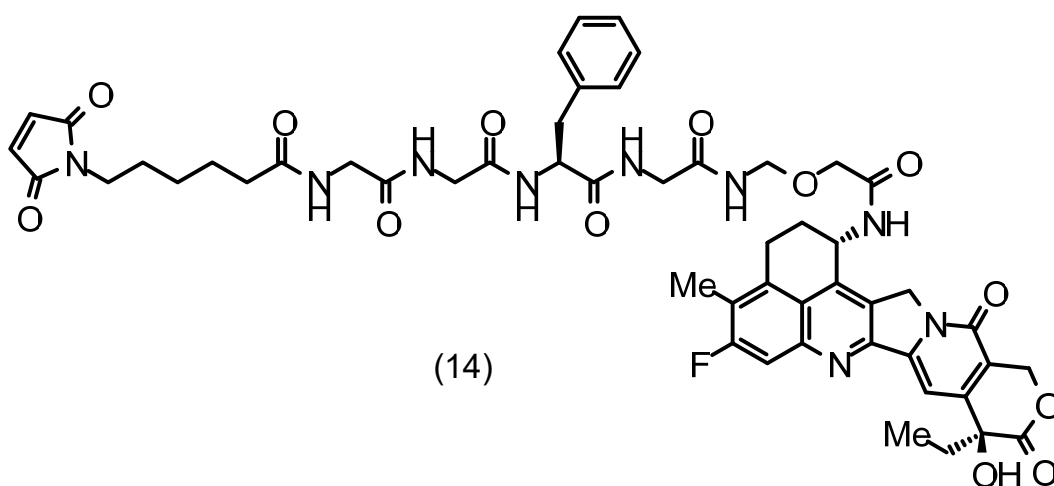


.

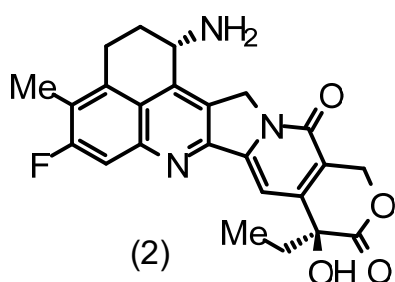
49. A compound represented by formula (8):



50. A method for producing a compound represented by formula (14):



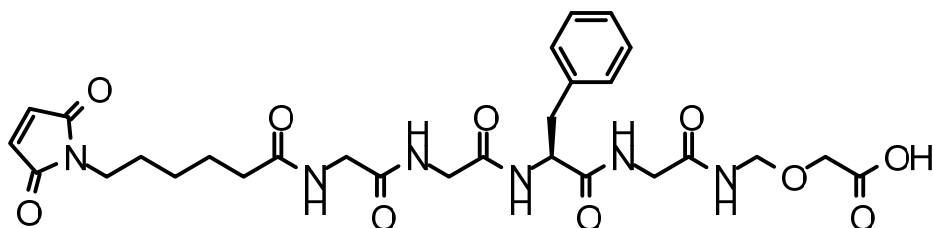
wherein a compound represented by formula (2):



produced by the method according to any one of claims 34 to 45 is used as a starting material, the method comprising the steps of:

condensing the compound represented by formula (2) with a compound represented by formula (13):

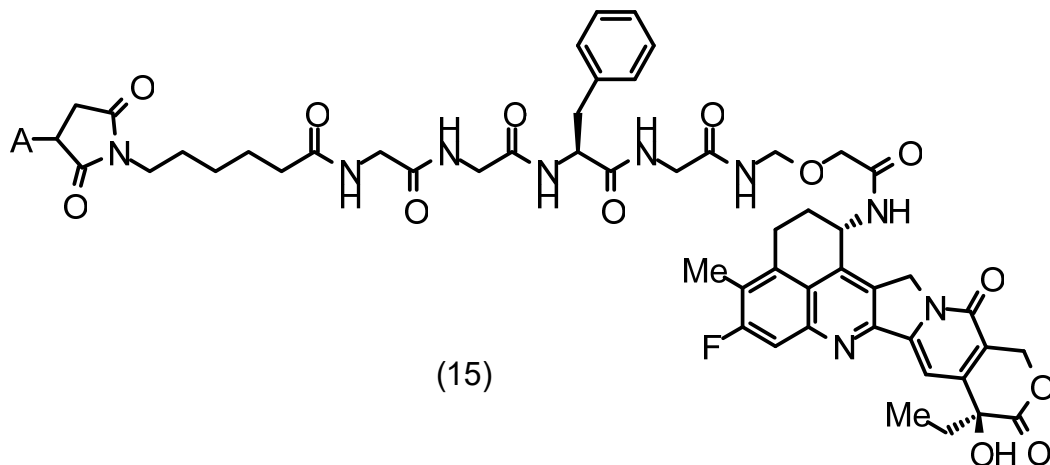
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(13)

to convert the compound represented by formula (2) into the compound represented by formula (14).

51. A method for producing an antibody-drug conjugate, in which a drug-linker represented by formula (15):

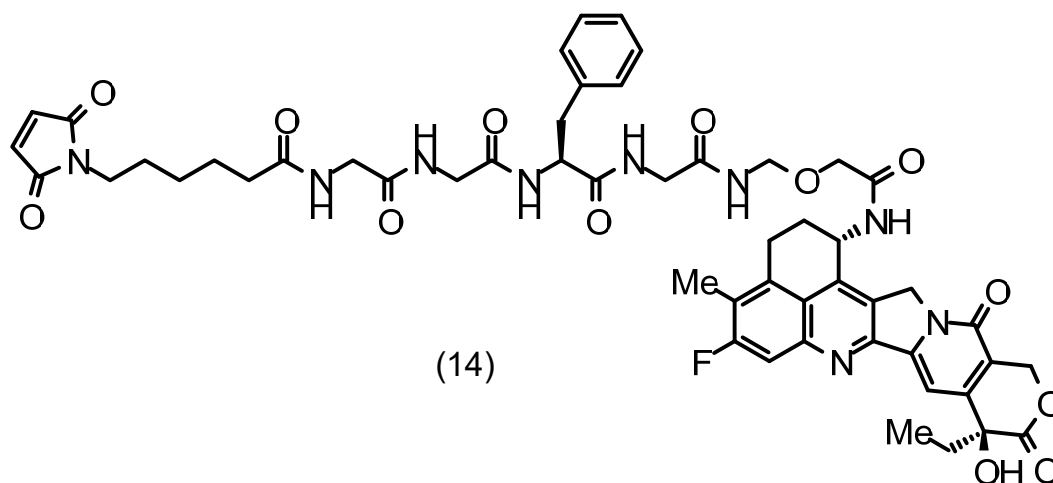


(15)

wherein A represents the connecting position to an antibody;

is conjugated to the antibody via a thioether bond,

wherein a compound represented by formula (14):



produced by the method according to claim 50 is used as a raw material,

the method comprising the steps of:

- (i) reducing an antibody; and then
- (ii) reacting the compound represented by formula (14) produced by the method with the reduced antibody.

52. The production method according to claim 51, wherein the antibody is an anti-HER2 antibody, an anti-HER3 antibody, an anti-TROP2 antibody, an anti-B7-H3 antibody, or an anti-GPR20 antibody.