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WO-A1-2010/147068
WO-A1-2012/039414
WO-A1-2017/104691

DESCRIPTION

Description

[TECHNICAL FIELD]

[0001] This invention relates to substituted polycyclic pyridone derivatives having cap-dependent endonuclease inhibitory activity for use in treating or preventing an influenza virus infection.

[BACKGROUND ART]

[0002] Influenza is an acute respiratory infectious disease caused by infection with an influenza virus. In Japan, millions of influenza-like patients are reported every winter, and influenza is accompanied with high morbidity and mortality. Influenza is a particularly important disease in a high risk population such as baby and elderly, a complication rate with pneumonia is high in elderly, and death with influenza is occupied with elderly in many cases.

[0003] As anti-influenza drugs, Symmetrel (trade name: Amantadine) and Flumadine (trade name: Rimantadine) which inhibit the denucleation process of a virus, and Oseltamivir (trade name: Tamiflu) and Zanamivir (trade name: Relenza) which are neuraminidase inhibitors suppressing virus budding and release from a cell are known. However, since problems of appearances of resistant strains and side effects, and worldwide epidemic of a new-type influenza virus having high pathogenicity and mortality are feared, development of an anti-influenza drug having a novel mechanism has been desired.

[0004] Since a cap-dependent endonuclease which is an influenza virus-derived enzyme is essential for virus proliferation, and has the virus-specific enzymatic activity which is not possessed by a host, it is believed that the endonuclease is suitable for a target of an anti-influenza drug. The cap-dependent endonuclease of an influenza virus has a host mRNA precursor as a substrate, and has the endonuclease activity of producing a fragment of 9 to 13 bases including a cap structure (not including the number of bases of the cap structure). This fragment functions as a primer of a virus RNA polymerase, and is used in synthesizing mRNA encoding a virus protein. That is, it is believed that a substance which inhibits the cap-dependent endonuclease inhibits synthesis of a virus protein by inhibiting synthesis of virus mRNA and, as a result, inhibits virus proliferation.

[0005] As the substance which inhibits the cap-dependent endonuclease, flutimide (Patent

Document 1 and Non-Patent Documents 1 and 2), 4-substituted 2,4-dioxobutanoic acid (Patent Document 2 and Non-Patent Documents 3 and 4), the compounds described in Patent Documents 3 to 12 and the like have been reported, but they have not yet led to clinical use as anti-influenza drugs. Patent Documents 9 and 12 describe compounds having a similar structure to the compounds described herein. Also, Patent Documents 13 to 15 describe compounds having a similar structure to the compounds described herein as a compound having integrase inhibitory activity, however, the documents do not describe cap-dependent endonuclease. In addition, Patent Document 16 and 17 describes an invention relating to compounds having a similar structure to the compounds described herein as a compound having cap-dependent endonuclease inhibitory activity.

[PRIOR ART DOCUMENTS]

[PATENT DOCUMENTS]

[0006]

Patent Document 1: GB2280435

Patent Document 2: US5475109

Patent Document 3: US20130090300

Patent Document 4: WO2013/057251

Patent Document 5: WO2013/174930

Patent Document 6: WO2014/023691

Patent Document 7: WO2014/043252

Patent Document 8: WO2014/074926

Patent Document 9: WO2014/108406

Patent Document 10: WO2014/108407

Patent Document 11: WO2014/108408

Patent Document 12: WO2015/038655

Patent Document 13: WO2005/016927

Patent Document 14: WO2006/066414

Patent Document 15: WO2007/049675

Patent Document 16: WO2010/147068

Patent Document 17: WO2012/039414

[NON-PATENT DOCUMENTS]

[0007]

Non-Patent Document 1: Tetrahedron Lett 1995, 36(12), 2005

Non-Patent Document 2: Tetrahedron Lett 1995, 36(12), 2009

Non-Patent Document 3: Antimicrobial Agents And Chemotherapy, De c. 1994, p.2827-2837

Non-Patent Document 4: Antimicrobial Agents And Chemotherapy, Ma y 1996, p.1304-1307

[SUMMARY OF THE INVENTION]

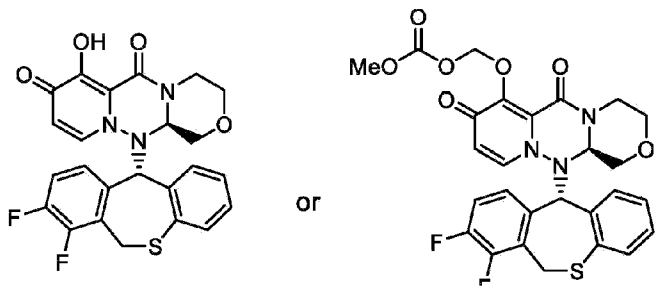
[PROBLEMS TO BE SOLVED BY THE INVENTION]

[0008] An object of the present invention is to provide compounds for use in treating or preventing an influenza virus infection. The scope of the invention is defined by the claims. Any references in the description to methods of treatment refer to the compounds, pharmaceutical compositions and medicaments of the present invention for use in a method for treatment of the human (or animal) body by therapy (or for diagnosis).

[MEANS FOR SOLVING THE PROBLEMS]

[0009] The present invention provides the below.

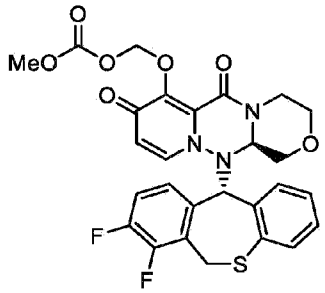
1. (1) A compound represented by following formula:



, or its pharmaceutically acceptable salt,

for use in treating or preventing an influenza virus infection.

2. (2) The compound for use according to (1), wherein the compound is represented by the formula:



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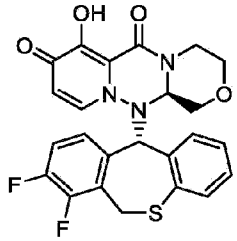
3. (3) The compound for use according to (1), wherein the compound is represented by the formula:



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4. (4) The compound or its pharmaceutically acceptable salt for use according to (1), wherein the use in treating or preventing an influenza virus infection is in a human.
5. (5) The compound for use according to (2) or (3), wherein the use in treating or preventing an influenza virus infection is in a human.

[0010] Described herein is a method for treating or preventing influenza infectious disease using the prodrug Compound II-6 and the parent Compound III-2 which exhibits anti influenza activity. The parent Compound III-2 is effective as an anti-influenza agent or an intermediate of the prodrug Compound II-6.

[EFFECT OF THE INVENTION]

[0011] The compounds described herein have an inhibitory activity on cap-dependent endonuclease. More preferred compound is prodrug Compound II-6, and the prodrug Compound II-6 becomes parent Compound III-2 having an inhibitory activity on cap-dependent endonuclease in vivo after administration, thus is effective as a therapeutic agent and/or preventive agent for influenza infectious disease.

[BRIEF DESCRIPTION OF DRAWINGS]

[0012]

[Figure 1] Figure 1 is a result of measuring the plasma concentration of compund III-2, after oral administration of prodrug Compound II-6, the parent compound of which is Compound III-2, to rat under non-fasting conditions.

[Figure 2] Figure 2 is a result of measuring the plasma concentration of Compound II-6, after oral administration of prodrug Compound II-6, the parent compound of which is Compound III-2, to rat under non-fasting conditions.

[BEST MODE FOR CARRYING OUT THE INVENTION]

[0013] The meaning of each term used in the present description is explained below. Each term is used in a unified sense, and is used in the same sense when used alone, or when used in combination of other term.

[0014] The term of "consisting of" means having only components.

[0015] The term of "comprising" means not restricting with components and not excluding undescribed factors.

[0016] The compound described herein isolated by optical resolution of tricyclic compounds substituted by the other tricyclic group improves cap-dependent endonuclease inhibitory activity.

[0017] The compound described herein is efficiently absorbed into the body after administration (for example, oral administration), and shows high high efficacy by introducing a group to form prodrug Compound II-6.

[0018] One or more hydrogen, carbon and/or other atoms in the compounds described herein may be replaced with isotopes of hydrogen, carbon and/or other atoms respectively. Examples of isotopes include hydrogen, carbon, nitrogen, oxygen, phosphorus, sulfur, fluorine, iodine and chlorine, such as ^{2}H, ^{3}H, ^{11}C, ^{13}C, ^{14}C, ^{15}N, ^{18}O, ^{17}O, ^{31}P, ^{32}P, ^{35}S, ^{18}F, ^{123}I and ^{36}Cl respectively. The compounds described herein for use in treating or preventing an influenza virus infection include compounds replaced with these isotopes. The compounds replaced with the above isotopes are useful as medicines and include all of radiolabeled compounds of the compound described herein. The "radiolabeled compounds" are useful for studies on metabolized drug pharmacokinetics, studies on binding assay and/or diagnostic tools.

[0019] A radiolabeled compound of the compounds described herein can be prepared using well-known methods in this field of the invention. For example, a tritium-labeled compound of the compounds described herein can be prepared by introducing a tritium to a certain compound described herein, through a catalytic dehalogenation reaction using a tritium. This method comprises reacting with an appropriately-halogenated precursor of the compound described herein with tritium gas in the presence of an appropriate catalyst, such as Pd/C, and in the presence or absent of a base. The other appropriate method of preparing a tritium-labeled compound can be referred to "Isotopes in the Physical and Biomedical Sciences, Vol. 1, Labeled Compounds (Part A), Chapter 6 (1987)". A ^{14}C-labeled compound can be prepared by using a raw material having ^{14}C.

[0020] The pharmaceutically acceptable salts of the compounds described herein include, for example, salts with alkaline metal (e.g., lithium, sodium, potassium or the like), alkaline earth metal (e.g., calcium, barium or the like), magnesium, transition metal (e.g., zinc, iron or the like), ammonia, organic bases (e.g., trimethylamine, triethylamine, dicyclohexylamine, ethanolamine, diethanolamine, triethanolamine, meglumine, ethylenediamine, pyridine, picoline, quinoline or the like) or amino acids, or salts with inorganic acids (e.g., hydrochloric acid, sulfuric acid, nitric acid, carbonic acid, hydrobromic acid, phosphoric acid, hydroiodic acid or the like) or organic acids (e.g., formic acid, acetic acid, propionic acid, trifluoroacetic acid, citric acid, lactic acid, tartaric acid, oxalic acid, maleic acid, fumaric acid, mandelic acid, glutaric acid, malic acid, benzoic acid, phthalic acid, ascorbic acid, benzenesulfonic acid, p-toluenesulfonic acid, methanesulfonic acid, ethanesulfonic acid or the like). Especially, salts with hydrochloric acid, sulfuric acid, phosphoric acid, tartaric acid, methanesulfonic acid and the like are included. These salts can be formed by the usual methods.

[0021] The compounds described herein or its pharmaceutically acceptable salts may form solvates (e.g., hydrates or the like) and/or crystal polymorphs. "Solvates" may be those wherein any numbers of solvent molecules (e.g., water molecules or the like) are coordinated with the compounds described herein. When the compounds described herein or its pharmaceutically acceptable salts are allowed to stand in the atmosphere, the compounds may absorb water, resulting in attachment of adsorbed water or formation of hydrates. Recrystallization of the compounds described herein or its pharmaceutically acceptable salts may produce crystal polymorphs.

(Method for producing compound described herein)

[0022] A method for producing the compound described herein will be exemplified below. As to the extraction and purification, treatment which is performed in a normal experiment of organic chemistry may be conducted.

[0023] Synthesis of the compound described herein can be carried out referring to the procedures known in the art.

[0024] As a raw material compound, commercially available compounds, compounds described in the present description, compounds described in the references cited in the present description, and other known compounds can be utilized.

[0025] When one wants to obtain a salt of the compound described herein, in the case where the compound described herein is obtained in a form of a salt, it may be purified as it is and, in the case where the compound described herein is obtained in a free form, a salt may be formed by a normal method by dissolving or suspending the compound in a suitable organic solvent, and adding an acid or a base.

[0026] In addition, the compound described herein and a pharmaceutically acceptable salt thereof are present in a form of adducts with water or various solvents (hydrate or solvate) in some cases, and these adducts are included in the present invention.

[0027] In Reference examples and Examples the meaning of each abbreviation is as follows.

Boc:	tert-butoxycarbonyl
DBU:	diazabicycloundecene
DMA:	N,N-dimethylacetamide
DMF:	N,N-dimethylformamide
OBn:	benzyloxy
THF:	tetrahydrofuran
T3P:	propyl phoshonic anhydride

[0028] The up and down of the "wedge" and "broken line wedge" indicates the absolute configuration.

[0029] The compound described herein has cap-dependent endonuclease inhibitory activity and is useful as a therapeutic or preventive agent for influenza.

[0030] The compound described herein not only has cap-dependent endonuclease inhibitory activity but also is useful as a medicine and has any or all of the following excellent characteristics:

1. a) The compound is a weak inhibitor of CYP enzymes (e.g., CYP1A2, CYP2C9, CYP2C19, CYP2D6, CYP3A4 and the like).
2. b) The compound demonstrates good pharmacokinetics, such as a high bioavailability, moderate clearance and the like.
3. c) The compound has a high metabolic stability.
4. d) The compound has no irreversible inhibitory action against CYP enzymes (e.g., CYP3A4) when the concentration is within the range described in the present description as the measurement conditions.

5. e) The compound has no mutagenicity.
6. f) The compound is associated with a low cardiovascular risk.
7. g) The compound has a high solubility.
8. h) The compound has no phototoxicity.

[0031] For the purpose of treating the above-mentioned diseases in humans, the compounds described herein may be administered orally as a powder, a granule, tablets, capsules, pills, a liquid and the like or parenterally as an injection, suppositories, a percutaneous drug, an inhalant and the like. The effective doses of the present compounds may be mixed with excipients suitable for the dosage form, such as fillers, binders, humectants, disintegrators, and lubricants, as appropriate, to form pharmaceutical preparations. For preparing an injection, sterilization is performed with a suitable carrier.

[0032] The pharmaceutical compositions described herein can be administered either orally or parenterally. For oral administration, commonly used dosage forms, such as tablets, granule, powder, and capsules, may be prepared according to conventional methods. For parenteral administration, any commonly used dosage form, such as an injection, may be suitably used. The compounds described herein can be suitably used as oral preparations because of their high oral absorbability.

[0033] The effective doses of the compounds described herein can be mixed with various pharmaceutical excipients suitable for the dosage form, such as fillers, binders, disintegrators, and lubricants, as appropriate, to form pharmaceutical compositions.

[0034] The dose depends on the condition of the disease, administration route, or age or weight of the patient. The usual oral dose for adults is 0.1 to 100 mg/kg per day, preferably 1 to 20 mg/kg per day.

[0035] The dose of the pharmaceutical composition described herein of the compounds described herein is preferably determined on the basis of the age and weight of the patient, type and severity of the disease, administration route and the like. The usual oral dose for adults is in the range of 0.05 to 100 mg/kg per day, preferably 0.1 to 10 mg/kg per day. The parenteral dose for adults significantly varies depending on the administration route but is usually in the range of 0.005 to 10 mg/kg per day, preferably 0.01 to 1 mg/kg per day. The dose may be administered once daily or may be divided into multiple daily doses.

[0036] The compound described herein can be used in combination with other drugs or the like (hereinafter referred to as combination drugs) to increase the activity of the compound, reduce the dose of the compound, or the like. In the case of treating influenza, the compound can be used combined with or in a coupled formulation with neuraminidase inhibitor (e.g., Oseltamivir, Zanamivir, Peramivir, Inabiru and the like); RNA-dependent RNA polymerase inhibitor (e.g., Favipiravir); M2 protein inhibitor (e.g., Amantadine); PB2 Cap binding inhibitor

(e.g., VX-787); anti-HA antibody (e.g., MHAA4549A); Immune agonists (e.g., Nitazoxanide) are also possible. In this case, the timing of administration for a compound described herein and the combination drug is not limited. They can be administered to the subjects to be treated, at a time or at different times. Furthermore, a compound described herein and the combination drug can be administered as two or more formulations independently comprising each active ingredient or a single formulation comprising each active ingredient.

[0037] The dose for combination drugs may be appropriately selected in reference to the clinical dose. The compounding ratio of the compounds described herein and co-administered drugs may be appropriately selected depending on the subject to be treated, administration route, disease to be treated, symptoms, combination of the drugs and the like. For administration in humans, for example, 1 part by weight of the compounds described herein may be used in combination with 0.01 to 100 parts by weight of co-administered drugs.

[0038] The present invention will be explained in more detail below by way of Examples, Reference examples, as well as Test Examples.

[0039] The NMR analysis obtained in each reference example and example was carried out in 300 MHz, and was measured using DMSO-d_6, $CDCl_3$.

[0040] The term RT represents a retention time at LC/MS: liquid chromatography/mass spectrometry, and was measured under the following conditions.

(Measurement Conditions)

[0041]

1. (1) Column: ACQUITY UPLC (Registered trademark) BEH C18 (1.7pm i.d.2.1x50mm) (Waters)

   Flow rate: 0.8 mL/min

   UV detection wavelength: 254nm

   Mobile phase: [A]: a 0.1% formic acid-containing aqueous solution, [B]: a 0.1% formic acid-containing acetonitrile solution

   Gradient: a linear gradient of 5% to 100% solvent [B] was carried out in 3.5 minutes, and 100% solvent [B] was kept for 0.5 minutes.

2. (2) Column: Shim-pack XR-ODS (2.2pm, i.d.50x3.0mm) (Shimadzu)

   Flow rate: 1.6 mL/min

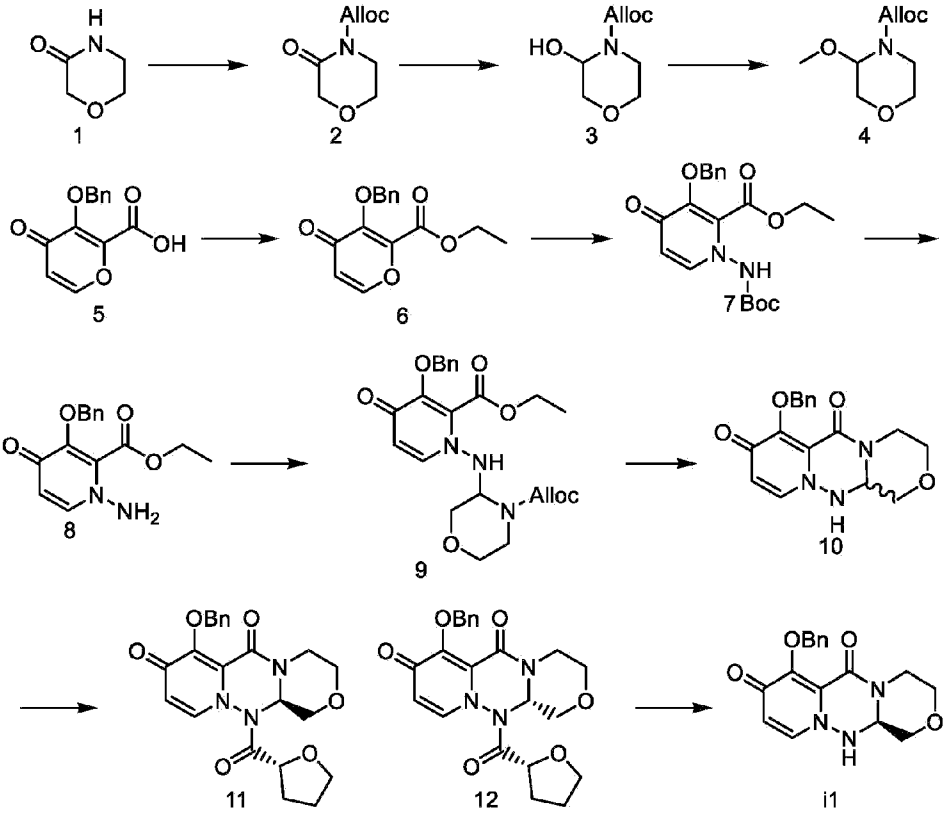
   UV detection wavelength: 254nm

Mobile phase: [A]: a 0.1% formic acid-containing aqueous solution, [B]: a 0.1% formic acid-containing acetonitrile solution

Gradient: a linear gradient of 10% to 100% solvent [B] was carried out in 3 minutes, and 100% solvent [B] was kept for 0.5 minutes.

Reference example 1

[0042]



First step

[0043] To a solution of Compound 1 (5.0 g, 49.5 mmol) in THF (100 mL) was added dropwise 1.62mol/L n-butyllithium in hexane (30.5 mL, 49.5 mmol) at - 78°C under a nitrogen atmosphere, and the mixture was stirred at -78°C for 2 hours. A solution of chloroformate allyl (5.96 g, 49.5 mmol) in THF (20 mL) was added dropwise thereto, and the mixture was stirred at -78°C for 2 hours. The mixture was quenched with a saturated aqueous solution of ammonium chloride, warmed up to room temperature, and extracted with ethyl acetate. The obtained organic layer was washed with brine, dried over anhydrous magunesium sulfate, and concentrated under reduced pressure to obtain Compound 2 (5.66 g, 62%).

1H-NMR(CDCl3)δ:3.83 (t, J = 8.0Hz, 2H), 3.92 (t, J = 8.0Hz, 2H), 4.26 (s, 2H), 4.78 (d, J = 8.0Hz, 2H), 5.30 (d, J = 12.0Hz, 1H), 5.44 (d, J = 16.0Hz, 1H), 5.93-6.03 (m, 1H),

Second step

[0044] To a solution of Compound 2 (6.6 g, 35.6 mmol) in THF (66 mL) was added dropwise 1.03mol/L DIBAL-H in hexane (45.0 mL, 46.3 mmol), and the mixture was stirred at -78°C for 1 hour. The mixture was quenched with acetone, an aqueous solution of Rochelle salt was added thereto. The mixture was stirred, and extracted with ethyl acetate. The obtained organic layer was washed with brine, dried over anhydrous magunesium sulfate, and concentrated under reduced pressure to obtain Compound 3 (6.21 g, 93%).
1H-NMR(CDCl3)δ:3.44 (br, 1H), 3.50-3.64 (m, 2H), 3.71 (br, 1H), 3.95 (d, J = 8.0Hz, 2H), 4.64 (d, J = 8.0Hz, 2H), 5.24 (d, J = 12.0Hz, 1H), 5.40 (d, J = 16.0Hz, 1H), 5.47 (d, J = 4Hz, 1H), 5.87-6.00 (m, 1H)

Third step

[0045] To a solution of Compound 3 (6.2 g, 33.1 mmol) in methanol (65 mL) was added p-Toluenesulfonic acid monohydrate (0.63 g, 3.31 mmol), and the mixture was stirred at room temperature over night. The mixture was quenched with an aqueous solution of sodium hydrogen carbonate, concentrated, and extracted with ethyl acetate. The obtained organic layer was washed with brine, dried over anhydrous magunesium sulfate, and concentrated under reduced pressure to obtain Compound 4 (5.77 g, 87%).
1H-NMR(CDCl3)δ:3.34 (s, 3H), 3.55 (br, 2H), 3.73-3.99 (m, 3H), 4.64 (d, J = 8.0Hz, 2H), 5.10-5.20 (m, 1H), 5.25 (d, J = 8.0Hz, 1H), 5.33 (d, J = 16Hz, 1 H), 5.88-6.05 (m, 1H)

Fourth step

[0046] To a solution of Compound 5 (20.0 g, 81 mmol) in DMF (100 mL) were added ethyl iodide (22.8 g, 146 mmol) and diazabicycloundecene (18.4 mL, 122 mmol), and the mixture was stirred at room temperature over night. The mixture was poured into 10% aqueous solution of ammonium chloride, and extracted with ethyl acetate. The obtained organic layer was washed with brine, dried over anhydrous magunesium sulfate, and concentrated under reduced pressure to obtain Compound 6 (22.3 g, 100%).
1H-NMR(CDCl3)δ:1.23 (t, J = 8.0Hz, 3H), 4.28 (q, J = 8.0Hz, 2H), 5.16 (s, 2 H), 6.57 (d, J = 4.0Hz, 1H), 7.28-7.48 (m, 5H), 8.21 (d, J = 4.0Hz, 1H).

Fifth step

[0047] To a solution of Compound 6 (500 mg, 1.82 mmol) in DMA (5.0 mL) were added pyridinium p-toluenesulfonate (1.37 g, 5.47 mmol) and Boc-hydrazine (361 mg, 2.74 mmol), and the mixture was stirred at 60°C for 14 hours. To the mixture was added water and the mixture was extracted with ethyl acetate.
The obtained organic layer was washed with a saturated aqueous solution of ammonium chloride and brine, dried over anhydrous magunesium sulfate, and concentrated under reduced pressure. The obtained residue was purified by silica gel column chromatography (chloroform-methanol) to obtain Compound 7 (519 mg, 73%).
1H-NMR(CDCl3)δ:1.24 (t, J = 8.0Hz, 3H), 1.46 (s, 9H), 4.26 (q, J = 8.0Hz, 2 H), 5.28 (s, 2H), 6.40 (d, J = 8.0Hz, 1H), 7.27-7.38 (m, 4H), 7.40-7.45 (m, 2 H).

Sixth step

[0048] Compound 7 (500 mg, 1.29 mmol) was dissolved in 4mol/L hydrogen chloride in ethyl acetate (5 mL), and the mixture was stirred at room temperature for 1 hour. The mixture was concentrated under reduced pressure. To the obtained residue was added a saturated aqueous solution of sodium hydrogen carbonate, and the mixture was extracted with dichloromethane. The obtained organic layer was washed with brine, dried over anhydrous magunesium sulfate, and concentrated under reduced pressure to obtain Compound 8 (369 mg, 99%).
1H-NMR(CDCl3)δ:1.26 (t, J = 8.0Hz, 3H), 4.31 (q, J = 8.0Hz, 2H), 5.24 (s, 2 H), 6.47 (d, J = 8.0, 1H), 7.28-7.44 (m, 5H), 7.64 (d, J = 8.0, 1H).

Seventh step

[0049] To a solution of Compound 8 (365 mg, 1.27 mmol) and Compound 4 (306 mg, 1.52 mmol) in acetonitrile (8 mL) was added dropwise tin chloride (0.223 mL, 1.90 mmol) at -25°C under a nitrogen atmosphere, and the mixture was stirred at -25°C for 45 minutes. The mixture was quenched with a saturated aqueous solution of sodium hydrogen carbonate, and dichloromethane was added thereto. The mixture was stirred at room temperature and filtered through Celite, and filtrate was extracted with dichloromethane. The obtained organic layer was washed with brine, dried over anhydrous magunesium sulfate, and concentrated under reduced pressure to obtain crude Compound 9. The obtained Compound 9 was dissolved in THF (8 mL), morpholine (1.10 mL, 12.7 mmol) and tetrakis(triphenylphosphine)palladium (146 mg, 0.127 mmol) were added thereto, and the mixture was stirred at room temperature for 2 hours. To the mixture was added diethyl ether (16 mL), and the presipitated solid was filtered and dried to obtain Compound 10 (418 mg, 100%).
1H-NMR(CDCl3)δ:2.90-2.99 (m, 1H), 3.13 (t, J = 12.0Hz, 1H), 3.40-3.46 (m, 1 H), 4.00-4.08 (m, 1H), 4.14 (d, J = 12.0Hz, 1H), 5.07 (s, 2H), 6.22 (d, J = 8. 0Hz, 1H), 7.29-7.40 (m, 3H), 7.56 (d, J = 8.0Hz, 2H), 7.71 (d, J = 8.0Hz, 1H)

Eighth step

[0050] To a suspension of (R)-2-Tetrahydrofurioic Acid (855 mg, 7.36 mmol) and Compound 10 (2.00 g, 6.11 mmol) in ethyl acetate (9 ml) were added pyridine (4.00 ml, 49.6 mmol) and T3P (50% in ethyl acetate, 11.0 ml, 18.5 mmol) at room temperature, and the mixture was stirred over night. The presipitated solid was filtered and washed with ethyl acetate (4 ml) and ethanol (4 ml). The obtained solid was suspended in ethanol (6 ml) and the suspention was stirred at room temperature for 6.5 hours. The suspention was filtered and the obtained solid was washed with ethanol (2 ml) twise to obtain Compound 11 (1.18 g, 45.4%).

^{1} H-NMR (DMSO)δ: 1.80-1.94(m, 2H), 1.95-2.14(m, 2H), 3.21-3.35-(m, 2H), 3.5 0-3.60(m, 1H), 3.70-3.82(m, 3H), 4.00-4.05(m, 1H), 4.32-4.38(m, 1H), 5.14(dd, J=10.8Hz, 21.6Hz, 2H), 5.76-5.81(m, 1H), 6.29(d; J=4.8Hz, 1H), 7.28-7.39(m, 3H), 7.48-7.54(m, 2H), 7.64-7.75(m, 1H)

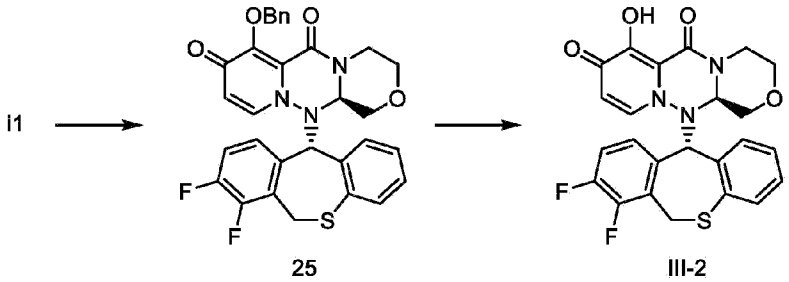
Ninth step

[0051] To a suspension of Compound 11 (500 mg, 1.18 mmol) in ethanol (3.5 ml) was added DBU (0.0035 ml, 0.023 mmol) at room temperature, and the mixture was stirred for 30 minutes. To the obtained suspension was added diisopropylether (6.5ml), and the mixture was stirred at room temperature for 30 minutes. The presipitated solid was filtered and washed with ethyl acetate (1.5 ml) twise to obtain Compound i1 (346 mg, 89.9%).

^{1} H-NMR (DMSO)δ: 2.80-3.00(m, 1H), 3.10-3.18(m, 1H), 3.38-3.50(m, 1H), 3.98 -4.08(m, 2H), 4.10-4.20(m, 1H), 4.76-4.84(m, 1H), 5.04-5.14(m, 2H), 6.22(m, J =7.6Hz, 1H), 7.27-7.40(m, 4H), 7.56-7.60(m, 2H), 7.70(d, J=7.6Hz, 1H)

Example 1

[0052]



First step

[0053] Compound i1 (1100 g, 3360 mmol) and 7,8-difluoro-6,11-dihydrodibenzothiepine-11-ol

(977 g, 3697 mmol) were suspended in 50wt% T3P in ethyl acetate (3208 g, 5041 mmol) and ethyl acetate (1.1 L). To the mixture was added methanesulfonic acid (436 ml, 6721 mmol) at room temperature and the mixture was stirred at 70°C for 5.5 hours. To the mixture was added water under ice-water bath and the mixture was stirred at room temperature for 1 hour. THF was added thereto and the mixture was extracted with ethyl acetate. The obtained organic layer was washed with water and 8% aqueous solution of sodium hydrogen carbonate, dried over anhydrous sodium sulfate, and concentrated under reduced pressure. The obtained residue was dissolved in THF (5.5 L) and potassium carbonate (790 g, 5713 mmol) was added thereto. The mixture was warmed up to 50°C, benzyl bromide (240 ml, 2016 mmol) was added dropwise thereto, and the mixture was stirred at 60°C for 8.5 hours. To the mixture was added dropwise 2mol/L aqueous solution of hydrochloric acid under ice-water bath, and the mixture was stirred at room temperature for 10 minutes and extracted with ethyl acetate. The obtained organic layer was washed with water and 8% aqueous solution of sodium hydrogen carbonate and dried over anhydrous magnesium sulfate. An activated carbon (Norit SX-2, 240 g) was added thereto, the mixture was filtered through Celite, and the filtrate was concentrated under reduced pressure To the obtained residue was added ethyl acetate and hexane and the presipitated solid was filtered to obtain Compound 25 (1019 g, 1776 mmol, 53%).

^{1} H-NMR ($CDCl_3$)δ: 2.88 (1H, t, J = 11.2 Hz), 3.28-3.39 (2H, m), 3.72 (1H, d, J = 12.6 Hz), 3.86 (1H, d, J = 9.6 Hz), 4.03 (1H, d, J = 13.9 Hz), 4.45 (1H , d, J = 8.6 Hz), 4.67 (1H, d, J = 13.1 Hz), 5.19-5.26 (2H, m), 5.45 (1H, d, J = 10.9 Hz), 5.63 (1H, d, J = 10.9 Hz), 5.77 (1H, d, J = 7.6 Hz), 6.40 (1H, d, J = 7.8 Hz), 6.68 (1H, t, J = 6.9 Hz), 6.94-7.01 (2H, m), 7.03-7.12 (3H, m), 7.29-7.38 (3H, m), 7.61 (2H, d, J = 7.1 Hz).

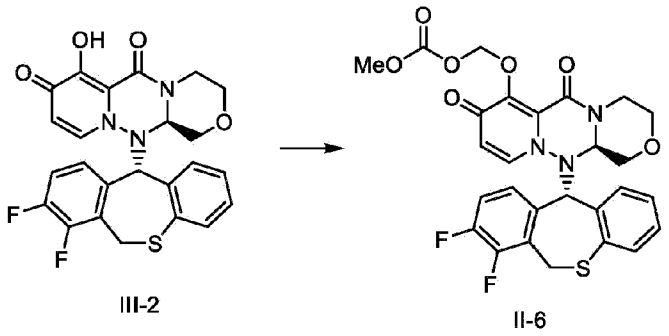
Second step

[0054] To a solution of Compound 25 (1200 g, 2092 mmol) in DMA (3.6 L) was added lithium chloride (443g, 10.5 mol) at room temperature, and the mixture was stirred at 80°C for 3 hours. To the mixture were added acetone (1.2L), 0.5mol/L aqueous solution of hydrochloric acid (6.0 L) and water (2.4 L) under ice-watre bath, and the mixture was stirred for 1 hour. The presipitated solid was filtered. The obtained solid was dissolved in chloroform, isopropyl ether was added thereto, and the presipitated solid was filtered to obtain Compound III-2 (950 g, 1965 mmol, 94%).

^{1}H-NMR ($CDCl_3$)δ: 2.99 (1H, dt, J = 17.5, 6.8 Hz), 3.47 (1H, td, J = 11.9, 2 .5 Hz), 3.60 (1H, t, J = 10.6 Hz), 3.81 (1H, dd, J = 11.9, 3.3 Hz), 3.96 (1H, dd, J = 11.0, 2.9 Hz), 4.07 (1H, d, J = 13.8 Hz), 4.58 (1H, dd, J = 10.0, 2.9 Hz), 4.67 (1H, dd, J = 13.5, 1.9 Hz), 5.26-5.30 (2H, m), 5.75 (1H, d, J = 7. 8 Hz), 6.69 (1H, d, J = 7.7 Hz), 6.83-6.87 (1H, m), 6.99-7.04 (2H, m), 7.07-7 .15 (3H, m).

Example 4

[0055]



[0056] To a suspention of Compound III-2 (1.00 g, 2.07 mmol) in DMA (5 ml) were added chloromethyl methyl carbonate (0.483 g, 3.10 mmol), potassium carbonate (0.572 g, 4.14 mmol) and potassium iodide (0.343 g, 2.07 mmol) and the mixture was stirred at 50°C for 6 hours. To the mixture was added DMA (1 ml) and the mixture was stirred for 6 hours. The mixture was cooled to room temperature, DMA (6 ml) was added thereto, and the mixture was stirred at 50°C for 5 minutes. The mixture was filtered. To the obtained filtrate were added 1mol/L aqueous solution of hydrochloric acid (10 ml) and water (4 ml) and the mixture was stirred for 1 hour. The presipitated solid was filtered and dried under reduced pressure at 60°C for 3 hours to obtain Compound II-6 (1.10g, 1.93 mmol, 93%).
1H-NMR (DMSO-D6) δ: 2.91-2.98 (1H, m), 3.24-3.31 (1H, m), 3.44 (1H, t, J = 10.4 Hz), 3.69 (1H, dd, J = 11.5, 2.8 Hz), 3.73 (3H, s), 4.00 (1H, dd, J = 10.8, 2.9 Hz), 4.06 (1H, d, J = 14.3 Hz), 4.40 (1H, d, J = 11.8 Hz), 4.45 (1 H, dd, J = 9.9, 2.9 Hz), 5.42 (1H, dd, J = 14.4, 1.8 Hz), 5.67 (1H, d, J = 6. 5 Hz), 5.72-5.75 (3H, m), 6.83-6.87 (1H, m), 7.01 (1H, d, J = 6.9 Hz), 7.09 (1H, dd, J = 8.0, 1.1 Hz), 7.14-7.18 (1H, m), 7.23 (1H, d, J = 7.8 Hz), 7.37-7 .44 (2H, m).

[0057] Prodrug Compound II-6 and/or parent Compound III-2 are useful for symptoms and/or diseases which are induced by influenza virus. For example, they are useful for treating and/or preventing, or improving symptoms of, cold-like symptoms accompanying fever, algor, headache, muscular pain, general malaise etc., airway inflammation symptoms such as pharyngalgia, nasal secretion, nasal congestion, cough, sputum etc., gastrointestinal symptoms such as abdominal pain, vomitus, diarrhea etc. and, further, complications accompanying secondary infection such as acute encephalopathy and pneumonia.

[0058] Since the prodrug Compound II-6 described herein has advantages that oral absorbability is high, good bioavailability is exhibited, good clearance is exhibited, and pulmonary transitivity is high, it can be an excellent medicament.

[0059] Since the parent Compound III-2 has the effects such as high inhibitory activity on cap structure-dependent endonuclease, and high selectivity due to a virus-specific enzyme, it can be a medicament having reduced side effects.

[0060] Further, since the compounds described herein also have advantages that metabolism stability is high, solubility is high, oral absorbability is high, good bioavailability is exhibited, good clearance is exhibited, pulmonary transitivity is high, a half life is long, a non-protein

binding rate is high, hERG channel inhibition is low, CYP inhibition is low, CPE (CytoPathic Effect) inhibiting effect is recognized, and/or negativity is exhibited in a phototoxicity test, an Ames test and a gene toxicity test, or toxicity such as liver damage is not caused. Therefore, the compounds described herein can be excellent medicaments.

[0061] The compounds described herein can be administered orally or parenterally. In the case of oral administration, the present compounds can be also used as a normal preparation, for example, as any dosage form of solid preparations such as tablets, powders, granules, capsules etc.; solutions; oleaginous suspensions; or liquid preparations such as syrups or elixirs etc. In the case of parenteral administration, the compounds described herein can be used as aqueous or oleaginous suspension injectables, or nose drops. Upon preparation of them, conventional excipients, binders, lubricants, aqueous solvents, oleaginous solvents, emulsifiers, suspending agents, preservatives, stabilizers etc. can be arbitrarily used. The pharmaceutical composition described herein can be produced by combining (for example, mixing) a therapeutically effective amount of the present compound with pharmaceutically acceptable carriers or diluents.

[0062] A dose of the compounds described herein is different depending on an administration method, an age, a weight and the state of a patient, and a kind of a disease and, usually, in the case of oral administration, about 0.05 mg to 3000 mg, preferably about 0.1 mg to 1000 mg for adult per day may be administered, if necessary, by division. In addition, in the case of parenteral administration, about 0.01 mg to 1000 mg, preferably about 0.05 mg to 500 mg for adult per day is administered.

Test Example 1: Measurement of cap-dependant endonuclease (CEN) inhibitory activity

1) Preparation of substrate

[0063] 30merRNA(5'-pp-[m2'-O]GAA UAU(-Cy3) GCA UCA CUA GUAAGC UUU GCU CUA-BHQ2-3': manufactured by Japan Bio Services Co., LTD.) in which G at a 5' end is diphosphate-modified, a hydroxy group at 2' position is methoxylation-modified, U sixth from a 5' end is labelled with Cy3, and a 3' end is labelled with BHQ2 was purchased, and a cap structure was added using ScriptCap system manufactured by EPICENTRE (a product was m7G [5']-ppp-[5'] [m2'-O]GAA UAU(-Cy3) GCA UCA CUA GUAAGC UUU GCU CUA(-BHQ2)-3'). This was separated and purified by denatured polyacrylamide gel electrophoresis, and used as a substrate.

2) Preparation of enzyme

[0064] RNP was prepared from a virus particle using standard method (Reference Document:

VIROLOGY(1976) 73, p327-338 OLGAM. ROCHOVANSKY). Specifically, A/WSN/33 virus (1×10^3 PFU/mL, 200 µL) was inoculated in a 10 days old embryonated chicken egg. After incubation at 37°C for 2 days, the allantoic fluid of the chicken egg was recovered. A virus particle was purified by ultracentrifugation using 20% sucrose, solubilized using TritonX-100 and lysolecithin, and an RNP fraction (50-70% glycerol fraction) was collected by ultracentrifugation using a 30-70% glycerol density gradient, and was used as an enzyme solution (containing approximately 1 nM PB1-PB2-PA complex).

3) Enzymatic reaction

[0065] An enzymatic reaction solution (2.5 µL) (composition: 53 mM Tris-hydrochloride (pH 7.8), 1 mM $MgCl_2$, 1.25 mM dithiothreitol, 80 mM NaCl, 12.5% glycerol, enzyme solution 0.15 µL) was dispensed into a 384-well plate made of polypropylene. Then, 0.5 µL of a test compound solution which had been serially diluted with dimethyl sulfoxide (DMSO) was added to the plate. As a positive control (PC) or a negative control (NC), 0.5 µL of DMSO was added to the plate respectively. Each plate was mixed well. Then, 2 µL of a substrate solution (1.4 nM substrate RNA, 0.05% Tween20) was added to initiate a reaction. After room temperature incubation for 60 minutes, 1 µL of the reaction solution was collected and added to 10 µL of a Hi-Di formamide solution (containing GeneScan 120 Liz Size Standard as a sizing marker: manufactured by Applied Biosystems (ABI)) in order to stop the reaction. For NC, the reaction was stopped in advance by adding EDTA (4.5 mM) before initiation of the reaction (all concentrations described above are final concentrations).

3) Measurement of inhibition ratio (IC_{50} value)

[0066] The solution for which the reaction was stopped was heated at 85°C for 5 minutes, rapidly cooled on ice for 2 minutes, and analyzed with an ABI PRIZM 3730 genetic analyzer. A peak of the cap-dependent endonuclease product was quantitated by analysis software ABI Genemapper, a CEN reaction inhibition ratio (%) of a test compound was obtained by setting fluorescent intensities of PC and NC to be 0% inhibition and 100% inhibition, respectively, an IC_{50} value was obtained using curve fitting software (XLfit2.0: Model 205 (manufactured by IDBS) etc.). The IC_{50} values of test substances being a parent compound, are shown in Table 1.

Test Example 2: CPE inhibitory effect confirming assay

<Material>

[0067]

- 2% FCS E-MEM (prepared by adding kanamycin and FCS to MEM (Minimum Essential Medium) (Invitrogen))
- 0.5% BSA E-MEM (prepared by adding kanamycin and BSA to MEM (Minimum Essential Medium) (Invitrogen))
- HBSS (Hanks' Balanced Salt Solution)
- MDBK cell

[0068] Cells were adjusted to the appropriate cell number (3×10^5/mL) with 2% FCS E-MEM.

- MDCK cell

[0069] After washing with HBSS two times, cells were adjusted to the appropriate cell number (5×10^5/mL) with 0.5% BSA E-MEM.

- Trypsin solution

[0070] Trypsin from porcine pancreas (SIGMA) was dissolved in PBS(-), and filtrated with a 0.45 μm filter.

- EnVision (PerkinElmer)
- WST-8 Kit (Kishida Chemical Co., Ltd.)
- 10% SDS solution

<Operation procedure>

• Dilution and dispensation of test sample

[0071] As a culture medium, 2% FCS E-MEM was used at the use of MDBK cells, and 0.5% BSA E-MEM was used at the use of MDCK cells. Hereinafter, for diluting virus, cells and a test sample, the same culture medium was used.

[0072] A test sample was diluted with a culture medium to an appropriate concentration in advance, and then 2 to 5-fold serial dilution on a 96 well plate (50 μL/well) was prepared. Two plates, one for measuring anti-Flu activity and the another for measuring cytotoxity, were

prepared. Each assay was performed triplicate for each drug.

[0073] At the use of MDCK cells, Trypsin was added to the cells to be a final concentration of 3 µg/mL only for measuring anti-Flu activity.

• Dilution and dispensation of influenza virus

[0074] An influenza virus was diluted with a culture medium to an appropriate concentration in advance, and each 50 µL/well was dispensed on a 96-well plate containing a test substance. Each 50 µL/well of a culture medium was dispensed on a plate containing a test substance for measuring cytotoxity.

• Dilution and dispensation of cell

[0075] Each 100 µL/well of cells which had been adjusted to the appropriate cell number was dispensed on a 96 well plate containing a test sample.

[0076] This was mixed with a plate mixer, and incubated in a CO2 incubator for 3 days for measuring anti-Flu activity and measuring cytotoxity.

• Dispensation of WST-8

[0077] The cells in the 96-well plate which had been incubated for 3 days was observed visually under a microscope, and appearance of the cells, the presence or absence of a crystal of test substance were checked. The supernatant was removed so that the cells were not absorbed from the plate.

[0078] WST-8 Kit was diluted 10-fold with a culture medium, and each 100 µL was dispensed into each well. After mixing with a plate mixer, cells were incubated in a CO2 incubator for 1 to 3 hours.

[0079] After incubation, regarding the plate for measuring anti-Flu activity, each 10 µL/well of a 10% SDS solution was dispensed in order to inactivate a virus.

• Measurement of absorbance

[0080] After the 96-well plate was mixed, absorbance was measured with EnVision at two wavelengths of 450 nm/620 nm.

<Calculation of each measurement item value>

[0081] The value was calculated using Microsoft Excel or a program having the equivalent calculation and processing ability, based on the following calculation equation.

- Calculation of effective inhibition concentration to achieve 50% influenza infected cell death (EC50)
  $EC50 = 10^{Z}$

[0082] For Compound III-2, measurement results of Test Example 1 and Test Example 2 are shown in Table 1.

[Table 1]

No.	CEN_IC50 nM	CPE_EC50 nM
III-2	1.93	1.13

[0083] Based on the above results, the parent Compound III-2 exhibits high cap-dependent endonuclease (CEN) inhibitory activity and high CPE inhibitory effect and thus can be a useful agent for treatment and/or prevention of symptom and/or disease induced by infection with influenza virus.

[0084] Biological test examples for compounds described herein were described below.

Test Example 3: CYP inhibition test

[0085] Using commercially available pooled human hepatic microsome, and employing, as markers, 7-ethoxyresorufin O-deethylation (CYP1A2), tolbutamide methyl-hydroxylation (CYP2C9), mephenytoin 4'-hydroxylation (CYP2C19), dextromethorphan O-demethylation (CYP2D6), and terfenedine hydroxylation (CYP3A4) as typical substrate metabolism reactions of human main five CYP enzyme forms (CYP1A2, 2C9, 2C19, 2D6, 3A4), an inhibitory degree of each metabolite production amount by a compound described herein was assessed.

[0086] The reaction conditions were as follows: substrate, 0.5 pmol/L ethoxyresorufin (CYP1A2), 100 pmol/L tolbutamide (CYP2C9), 50 pmol/L S-mephenytoinmephenitoin (CYP2C19), 5 pmol/L dextromethorphan (CYP2D6), 1 pmol/L terfenedine (CYP3A4); reaction time, 15 minutes; reaction temperature, 37°C; enzyme, pooled human hepatic microsome 0.2 mg protein/mL; concentration of a compound described herein, 1, 5, 10, 20 pmol/L (four points).

[0087] Each five kinds of substrates, human hepatic microsome, or a compound described herein in 50 mmol/L Hepes buffer as a reaction solution was added to a 96-well plate at the composition as described above, NADPH, as a cofactor was added to initiate metabolism reactions as markers and, after the incubation at 37°C for 15 minutes, a methanol/acetonitrile = 1/1 (v/v) solution was added to stop the reaction. After the centrifugation at 3000 rpm for 15 minutes, resorufin (CYP1A2 metabolite) in the supernatant was quantified by a fluorescent multilabel counter and toltributamide hydroxide (CYP2C9P metabolite), mephenytoin 4' hydroxide (CYP2C19 metabolite), dextromethorphan (CYP2D6 metabolite), and terfenadine alcohol (CYP3A4 metabolite) were quantified by LC/MS/MS.

[0088] Addition of only DMSO being a solvent dissolving a compound described herein to a reaction system was adopted as a control (100%), remaining activity (%) was calculated at each concentration of a compound described herein added as the solution and IC50 was calculated by reverse presumption by a logistic model using a concentration and an inhibition rate.

(Result)

Compund III-2: five kinds >20pmol/L

Test Example 4: BA test

Materials and methods for experiments to evaluate oral absorption

[0089]

1. (1) Experimental animals: mice or SD rats were used.
2. (2) Rearing condition: mice or SD rats were allowed free access to solid feed and sterilized tap water.
3. (3) Setting of dosage and grouping: Oral administration and intravenous administration were performed with the predetermined dosage. Grouping was set as below. (Dosage was changed per compound)

   Oral administration 1 to 30 mg/kg (n= 2 to 3)

   Intravenous administration 0.5 to 10 mg/kg (n= 2 to 3)

4. (4) Preparation of administration solutions: Oral administration was performed as solution or suspension. Intravenous administration was performed after solubilization.
5. (5) Routes of administration: Oral administration was performed mandatory into the

stomach by oral sonde. Intravenous administration was performed from caudal vein by syringes with needle.

6. (6) Evaluation items: Blood was collected serially and concentration of a compound described herein in plasma was measured by LC/MS/MS.
7. (7) Statistical analysis: About transition of concentration of a compound described herein in plasma, the area under the plasma concentration versus time curve (AUC) was calculated by non-linear least-squares method program, WinNonlin (a registered trademark), and bioavailability (BA) of a compound described herein was calculated from AUCs of the oral administration group and the intravenous administration group.

(Result)

Compound II-6: 14.9%

Compound III-2: 4.2%

[0090] Based on the above results, the prodrug Compound II-6 had improved bioavailability other than the parent Compound III-2.

[0091] Therefore, the compound described herein has excellent oral absorbabil ity and can be a useful agent for treatment and/or prevention of symptom a nd/or disease induced by infection with influenza virus.

Test Example 5: Metabolism Stability Test

[0092] Using commercially available pooled human hepatic microsomes, a compound described herein was reacted for a constant time, and a remaining rate was calculated by comparing a reacted sample and an unreacted sample, thereby, a degree of metabolism in liver was assessed.

[0093] A reaction was performed (oxidative reaction) at 37 °C for 0 minute or 30 minutes in the presence of 1 mmol/L NADPH in 0.2 mL of a buffer (50 mmol/L Tris-HCl pH 7.4, 150 mmol/L potassium chloride, 10 mmol/L magnesium chloride) containing 0.5 mg protein/mL of human liver microsomes. After the reaction, 50 µL of the reaction solution was added to 100 pL of a methanol/acetonitrile = 1/1 (v/v), mixed and centrifuged at 3000 rpm for 15 minutes. The compound described herein in the supernatant was quantified by LC/MS/MS or Solid Phase Extraction (SPE)/MS, and a remaining amount of the compound described herein after the

reaction was calculated, letting a compound amount at 0 minute reaction time to be 100%. Hydrolysis reaction was performed in the absence of NADPH and glucuronidation reaction was in the presence of 5 mM UDP-glucuronic acid in place of NADPH, followed by similar operations.
(Result) % inhibition was shown at 2μmol/L of test compound.

Compound III-2: 90.1%

Test Example 6: CYP3A4 fluorescent MBI test

[0094] The CYP3A4 fluorescent MBI test is a test of investigating enhancement of CYP3A4 inhibition of a compound described herein by a metabolism reaction, and the test was performed using, as CYP3A4 enzyme expressed in Escherichia coli and employing, as an index, a reaction in which 7-benzyloxytrifluoromethylcoumarin (7-BFC) is debenzylated by the CYP3A4 enzyme to produce a metabolite, 7-hydroxytrifluoromethylcoumarin (HFC) emitting fluorescent light.

[0095] The reaction conditions were as follows: substrate, 5.6 pmol/L 7-BFC; pre-reaction time, 0 or 30 minutes; reaction time, 15 minutes; reaction temperature, 25°C (room temperature); CYP3A4 content (expressed in Escherichia coli), at pre-reaction 62.5 pmol/mL, at reaction 6.25 pmol/mL (at 10-fold dilution); test drug concentration of a compound described herein, 0.625, 1.25, 2.5, 5, 10, 20 pmol/L (six points).

[0096] An enzyme in a K-Pi buffer (pH 7.4) and a solution of a compound described herein as a pre-reaction solution were added to a 96-well plate at the above composition of the pre-reaction, a part of it was transferred to another 96-well plate so that it was 1/10 diluted with a substrate and a K-Pi buffer, NADPH as a co-factor was added to initiate a reaction as an index (without preincubation) and, after a predetermined time of a reaction, acetonitrile/0.5 mol/L Tris (trishydroxyaminomethane) = 4/1 (V/V) was added to stop the reaction. In addition, NADPH was added to a remaining preincubation solution to initiate a preincubation (with preincubation) and, after a predetermined time of a preincubation, a part was transferred to another plate so that it was 1/10 diluted with a substrate and a K-Pi buffer to initiate a reaction as an index. After a predetermined time of a reaction, acetonitrile/0.5 mol/L Tris (trishydroxyaminomethane) = 4/1 (V/V) was added to stop the reaction. For the plate on which each index reaction had been performed, a fluorescent value of 7-HFC which is a metabolite was measured with a fluorescent plate reader. (Ex = 420 nm, Em = 535 nm).

[0097] Addition of only DMSO which is a solvent dissolving a compound described herein to a reaction system was adopted as a control (100 %), remaining activity (%) was calculated at each concentration of a compound described herein added as the solution, and IC_{50} was calculated by reverse-presumption by a logistic model using a concentration and an inhibition

rate. When a difference between IC_{50} values is 5 pmol/L or more, this was defined as (+) and, when the difference is 3 μmol/L or less, this was defined as (-).

(Result)

Compound III-2: (-)

Test Example 7: Fluctuation Ames Test

[0098] Mutagenicity of compounds described herein was evaluated.

[0099] 20 pL of freezing-stored rat typhoid bacillus (Salmonella typhimurium TA98 strain, TA100 strain) was inoculated on 10 mL of a liquid nutrient medium (2.5% Oxoid nutrient broth No.2), and this was cultured before shaking at 37°C for 10 hours. 9 mL of a bacterial solution of the TA98 strain was centrifuged (2000 × g, 10 minutes) to remove a culturing solution. The bacteria was suspended in 9 mL of a Micro F buffer (K_2HPO_4: 3.5 g/L, KH_2PO_4: 1 g/L, $(NH_4)_2SO_4$: 1 g/L, trisodium citrate dehydrate: 0.25 g/L, $MgSO_4 \cdot 7H_2O$: 0.1 g/L), the suspension was added to 110 mL of an Exposure medium (Micro F buffer containing Biotin: 8 pg/mL, histidine: 0.2 pg/mL, glucose: 8 mg/mL). The TA100 strain was added to 120 mL of the Exposure medium relative to 3.16 mL of the bacterial solution to prepare a test bacterial solution. Each 12 pL of DMSO solution of a compound described herein (several stage dilution from maximum dose 50 mg/mL at 2 to 3 fold ratio), DMSO as a negative control, and 50 pg/mL of 4-nitroquinoline-1-oxide DMSO solution for the TA98 strain, 0.25 μg/mL of 2-(2-furyl)-3-(5-nitro-2-furyl)acrylamide DMSO solution for the TA100 strain under the non-metabolism activating condition, 40 pg/mL of 2-aminoanthracene DMSO solution for the TA98 strain, 20 pg/mL of 2-aminoanthracene DMSO solution for the TA100 strain under the metabolism activating condition as a positive control, and 588 pL of the test bacterial solution (a mixed solution of 498 pl of the test bacterial solution and 90 μL of S9 mix under the metabolism activating condition) were mixed, and this was shaking-cultured at 37°C for 90 minutes. 460 pL of the bacterial solution exposed to a compound described herein was mixed with 2300 pL of an Indicator medium (Micro F buffer containing biotin: 8 pg/mL, histidine: 0.2 pg/mL, glucose: 8 mg/mL, Bromo Cresol Purple: 37.5 pg/mL), each 50 pL was dispensed into microplate 48 wells/dose, and this was subjected to stationary culturing at 37°C for 3 days. Since a well containing a bacterium which has obtained the proliferation ability by mutation of an amino acid (histidine) synthesizing enzyme gene turns from purple to yellow due to a pH change, the bacterium proliferation well which has turned to yellow in 48 wells per dose is counted, and was assessed by comparing with a negative control group. (-) means that mutagenicity is negative and (+) is positive.

(Result)

Compound III-2: (-)

Test Example 8: hERG Test

[0100] For the purpose of assessing risk of an electrocardiogram faT interval prolongation of the compound described herein, effects of the compound described herein on delayed rectifier K+ current (I_{Kr}), which plays an important role in the ventricular repolarization process, was studied using HEK293 cells expressing human ether-a-go-go related gene (hERG) channel.

[0101] After a cell was retained at a membrane potential of -80 mV by whole cell patch clamp method using an automated patch clamp system (PatchXpress 7000A, Axon Instruments Inc.), I_{Kr} induced by depolarization pulse stimulation at +40 mV for 2 seconds and, further, repolarization pulse stimulation at -50 mV for 2 seconds, was recorded. After the generated current was stabilized, extracellular solution (NaCl: 135 mmol/L, KCl: 5.4 mmol/L, NaH_2PO_4: 0.3 mmol/L, $CaCl_2 \cdot 2H_2O$: 1.8 mmol/L, $MgCl_2 \cdot 6H_2O$: 1 mmol/L, glucose: 10 mmol/L, HEPES (4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid): 10 mmol/L, pH=7.4), in which the compound described herein had been dissolved at an objective concentration, was applied to the cell at room temperature for 10 minutes. From the recording Ixr, an absolute value of the tail peak current was measured based on the current value at the resting membrane potential using analysis software (DataXpress ver.1, Molecular Devices Corporation). Further, the % inhibition relative to the tail peak current before application of the compound described herein was calculated, and compared with the vehicle-applied group (0.1% dimethyl sulfoxide solution) to assess influence of the compound of the present invention on I_{Kr}.
(Result) % inhibition was shown at 0.3 to 10 pM of test compound.

Compound III-2: 7.9%

Test Example 9: Solubility test

[0102] The solubility of the compound described herein was determined under 1% DMSO addition conditions. A 10 mmol/L solution of the compound was prepared with DMSO, and 2 pL of the solution of the compound described herein was added, respectively, to 198 pL of JP-1 solution (water were added to 2.0 g of sodium chloride and 7.0 mL of hydrochloric acid to reach 1000 mL) and JP-2 solution (1 volume of water were added to 1 volume of the solution which 3.40 g of potassium dihydrogen phosphate and 3.55 g of anhydrous disodium hydrogen phosphate to reach 1000 mL). The mixture was shaked for 1 hour at a room temperature, and

the mixture was filtered. The filtrate was ten-fold diluted with methanol/water = 1/1(v/v), and the compound concentration in the filtrate was measured with LC/MS or SPE/MS by the absolute calibration method.

(Result)

Compound III-2: 42.2pmol/L

Test Example 10: Powder solubility test

[0103] Appropriate amounts of the compound described herein was put into vials and 200pL of JP-1st Fluid (water was added to 2.0g of sodium chloride in 7.0mL of hydrochloride acid to reach 1000 mL), JP-2nd Fluid (water was added to 500 mL of phosphate buffer solution with a pH of 6.8) and 20mmol /L sodium taurocholate (TCA) / JP-2nd Fluid (JP-2nd Fluid was added to 1.08g of TCA in JP-2nd Fluid to reach 100mL) was added to each vial. When the compound was completely dissolved, appropriate amount of compound was added. After shaken for 1 hour at 37°C, the mixture was filtered and 100μL of methanol was added to 100μL of each filtrate (double dilution). Dilution magnification was changed if necessary. After it was confirmed whether there were air bubbles and precipitates in the vials, the vials were shaken with tight stopper. The compound concentration was determined with HPLC by the absolute calibration method.

(Result)

Compund III-2: JP-1 solution; 7.1 μg/mL, JP-2 solution; 4.4 pg/mL, 20 mmol/L TCA/JP-2 solution; 16.1 μg/mL

Test Example 11: Ames test

[0104] Ames test was performed by using Salmonellas (Salmonella typhimurium) TA 98, TA100, TA1535 and TA1537 and Escherichia coli WP2uvrA as test strains with or without metabolic activation in the pre-incubation method to check the presence or absence of gene mutagenicity of compounds described herein.

(Result)

Compound III-2: (-)

Test Example 12: Light hemolysis test

[0105] The compound described herein was dissolved at target concentrations and was mixed with a 2.5 v/v% suspension of red blood cells prepared from a defibrinated blood of sheep on a microplate at concentrations of 0.0008 to 0.1 w/v%. The mixtures were exposed to 10 J/cm^2 of UV-irradiation within a range of wavelength 290 to 400 nm, UVA and UVB using ultra violet fluorescent lamps, GL20SE and FL20S-BLB lamps manufactured by Sankyo Denki Co., Ltd. and Panasonic Corporation, respectively. After the completion of the irradiation, the mixtures were centrifuged, and a supernatant of the mixture was collected and was located on a microplate. The phototoxicity was assessed by measuring an absorbance at wavelength of 540 nm and 630 nm in the supernatant. The absorbance data at wavelength of 540 nm and 630 nm were used as indicators of biomembrane damage (photohemolysis %) and hyperoxidation of lipid membrane (methemoglobin formation), respectively. The criteria of phototoxicity was as follows; It was judged to be non-phototoxic (-) when the photohemolysis % < 10 and the maximal change in the absorbance at 630 nm (ΔOD) < 0.05 were observed. It was judged to be non-phototoxic (+) when the photohemolysis was more than 10% and the maximal change in the absorbance at 630 nm (ΔOD) was more than 0.05.

(Result)

Compound III-2: (-)

[0106] Figures 1 and 2 show a result of measuring the plasma concentration of Compound III-2 and Compound II-6 after oral administration of prodrug Compound II-6, the parent compound of whch is Compound III-2, to rat under non-fasting conditions.

[0107] In addition, the concentration of Compound II-6 in all plasma samples was a determination limit or less. Therefore, prodrug Compound II-6, the parent compound of which is Compund III-2 is found to have changed promptly to Compound III-2 in vivo after administration (see Figure 2).

[0108] Based on the above test results, it was revealed that the compound converted into prodrug Compound II-6 was absorbed into the body after oral administration, and rapidly converted into a parent Compound III-2 in the blood. Therefore, the compound described herein can be a useful agent for treatment and/or prevention of symptom and/or disease

induced by infection with influenza virus.

Test Example 13: Intravenous Administration Test

Examined experimental materials and method of intravenous administration test

[0109]

1. (1) Animals used: SD rats were used.
2. (2) Rearing conditions: Pellets and sterilized tap water were fed to SD rats ad libitum.
3. (3) Dosage and grouping: A predetermined dosage was intravenously administered. Groups were set as follows. (Dosage varied for each compound)
   Intravenous administration 0.5-1 mg/kg (n = 2-3)
4. (4) Preparation of administration solution: Intravenous administration was performed after solubilization.
5. (5) Administration method: Intravenous administration was performed with a needle-equipped syringe on the caudal vein.
6. (6) End point: Blood was collected over time, and the plasma concentration of the compound described herein was measured using LC/MS/MS.
7. (7) Statistical analysis: As for the transition of the plasma concentration of the compound described herein, the total body clearance (CLtot) and the elimination half-life (t1/2, z) were calculated using nonlinear least-squares program WinNonlin (R).

(Results)

Compound No. III-2:

[0110]

CLtot: 16.4 mL/min/kg

t1/2, z: 3.4 hours

[0111] From the above results, it was found that Compound III-2 is a compound having a low total body clearance and a long half-life.

[0112] Therefore, the compound described herein has excellent persistence and can be a useful agent for treatment and/or prevention of symptom and/or disease induced by infection with influenza virus.

Formulation Example

[0113] The following Formulation Examples are only exemplified and not intended to limit the scope of the invention.

Formulation Example 1: Tablets

[0114] The compounds described herein, lactose and calcium stearate are mixed. The mixture is crushed, granulated and dried to give a suitable size of granules. Next, calcium stearate is added to the granules, and the mixture is compressed and molded to give tablets.

Formulation Example 2: Capsules

[0115] The compounds described herein, lactose and calcium stearate are mixed uniformly to obtain powder medicines in the form of powders or fine granules. The powder medicines are filled into capsule containers to give capsules.

Formulation Example 3: Granules

[0116] The compounds described herein, lactose and calcium stearate are mixed uniformly and the mixture is compressed and molded. Then, it is crushed, granulated and sieved to give suitable sizes of granules.

Formulation Example 4: Orally disintegrated tablets

[0117] The compounds described herein and crystalline cellulose are mixed, granulated and tablets are made to give orally disintegrated tablets.

Formulation Example 5: Dry syrups

[0118] The compounds described herein and lactose are mixed, crushed, granulated and sieved to give suitable sizes of dry syrups.

Formulation Example 6: Injections

[0119] The compounds described herein and phosphate buffer are mixed to give injection.

Formulation Example 7: Infusions

[0120] The compounds described herein and phosphate buffer are mixed to give injection.

Formulation Example 8: Inhalations

[0121] The compound described herein and lactose are mixed and crushed finely to give inhalations.

Formulation Example 9: Ointments

[0122] The compounds described herein and petrolatum are mixed to give ointments.

Formulation Example 10: Patches

[0123] The compounds described herein and base such as adhesive plaster or the like are mixed to give patches.

[Industrial Applicability]

[0124] The compound described herein has cap-dependent endonuclease (CEN) inhibitory activity after absorption into the body. The compound described herein is a useful agent for treatment and/or prevention of symptom and/or disease induced by infection with influenza virus.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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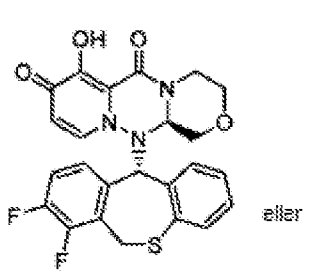
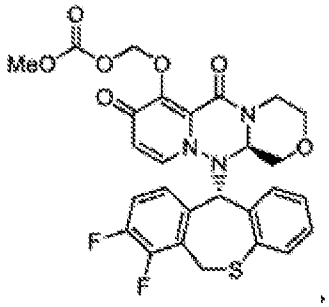
Patentkrav

1. Forbindelse repræsenteret ved følgende formel:

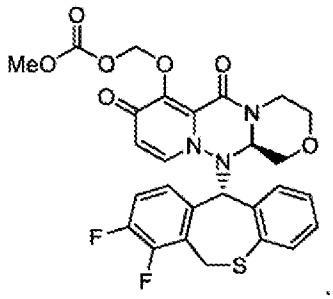


eller

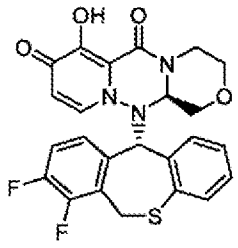


eller dets farmaceutisk acceptable salt,
til brug ved behandling eller forebyggelse af en influenzavirusinfektion.

2. Forbindelse til anvendelse ifølge krav 1, hvor forbindelsen er repræsenteret ved formlen:



3. Forbindelse til anvendelse ifølge krav 1, hvor forbindelsen er repræsenteret ved formlen:



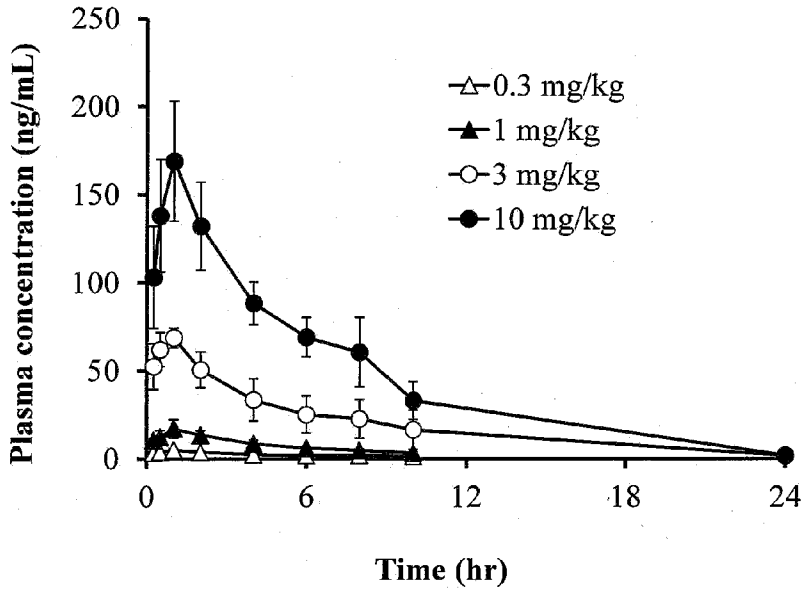
4. Forbindelse eller dens farmaceutisk acceptable salt til anvendelse ifølge krav 1, hvor anvendelsen til behandling eller forebyggelse af en influenzavirusinfektion er i et menneske.

5. Forbindelse til anvendelse ifølge krav 2 eller 3, hvor anvendelsen til behandling eller forebyggelse af en influenzavirusinfektion er i et menneske.

DRAWINGS

Drawing

[Figure 1]



[Figure 2]

Time	Plasma concentration (ng/mL)			
(hr)	0.3 mg/kg	1 mg/kg	3 mg/kg	10 mg/kg
0.25	BLQ	BLQ	BLQ	BLQ
0.5	BLQ	BLQ	BLQ	BLQ
1	BLQ	BLQ	BLQ	BLQ
2	BLQ	BLQ	BLQ	BLQ
4	BLQ	BLQ	BLQ	BLQ
6	BLQ	BLQ	BLQ	BLQ
8	BLQ	BLQ	BLQ	BLQ
10	BLQ	BLQ	BLQ	BLQ
24	BLQ	BLQ	BLQ	BLQ

BLQ : below the lower limit of quantification (< 0.500 ng/mL)