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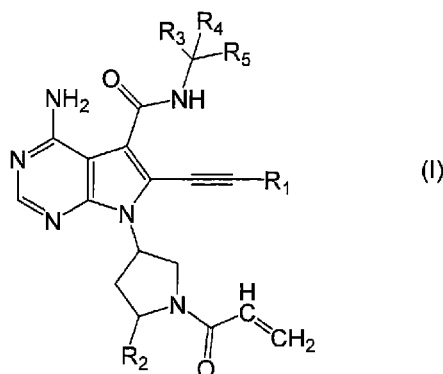
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(54) Title: PYRIMIDINE COMPOUND-CONTAINING COMBINATION TO BE USED IN TUMOR TREATMENT

(54) 発明の名称: 腫瘍の治療に使用されるピリミジン化合物を含む組み合わせ



(57) Abstract: Provided is a tumor treatment method using a pyrimidine compound or a salt thereof. An antitumor agent that contains a pyrimidine compound represented by general formula (I) or a salt thereof, said antitumor agent being to be administered in combination with another antitumor agent. (In the formula: R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group; R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having, as substituent(s), one to five C1-C4 alkoxy groups or one to five fluorine atoms, or a C1-C6 alkoxy group; R₃ represents a hydrogen atom or a C1-C4 alkyl group optionally having, as substituent(s), one to five fluorine atoms; R₄ represents a hydrogen atom or a C1-C4 alkyl group; and R₅ represents a phenyl group optionally having one to three substituents selected from fluorine and chlorine atoms.)

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添付公開書類：

- 一 国際調査報告（条約第21条(3)）
- 一 明細書の別個の部分として表した配列リスト（規則5.2(a)）

(57) 要約：ピリミジン化合物又はその塩を用いた腫瘍の治療方法を提供する。一般式（I）で表されるピリミジン化合物又はその塩を含む抗腫瘍剤であって、他の抗腫瘍剤と併用投与されるための、抗腫瘍剤である。（式中、 R_1 は、置換基としてC 1－C 4アルコキシ基を有しても良いC 1－C 4アルキル基、又はC 3－C 4シクロアルキル基を示し； R_2 は、水素原子、ハロゲン原子、置換基としてC 1－C 4アルコキシ基若しくはフッ素原子をそれぞれ1から5個有しても良いC 1－C 6アルキル基、又はC 1－C 6アルコキシ基を示し； R_3 は、水素原子、又は置換基としてフッ素原子を1から5個有しても良いC 1－C 4アルキル基を示し； R_4 は、水素原子、又はC 1－C 4アルキル基を示し； R_5 は、フッ素原子及び塩素原子から選択される置換基を1から3個有してもよいフェニル基を示す。）

DESCRIPTION

PYRIMIDINE COMPOUND-CONTAINING COMBINATION TO BE USED IN TUMOR TREATMENT

Technical Field

[0001]

The present invention relates to a combination of a pyrimidine compound or a salt thereof and other antitumor agent for use in the treatment of tumor, and an antitumor effect potentiator for other antitumor agent.

Background Art

[0002]

HER2 (which is also referred to as "ErbB2") is receptor tyrosine kinase belonging to the ErbB family.

HER2 is considered to be a proto-oncogene. It has been reported that HER2 gene amplification, overexpression, mutation and the like occur in various types of cancers. From non-clinical and clinical research data, it is considered that an activation of HER2 and downstream signals plays an important role in the survival and/or proliferation, etc. of cancer cells associated with the genetic abnormality, overexpression and the like of HER2 (Non Patent Literature 1).

Accordingly, an inhibitor capable of regulating the kinase activity of HER2 is assumed to inhibit HER2 and downstream signals in cancer cells having HER2 gene amplification, overexpression or mutation, so as to exhibit antitumor effects on the cancer cells. Therefore, such an inhibitor is considered to be useful for the treatment, life-prolonging, or QOL improvement of cancer patients.

[0003]

It has been reported that brain metastasis occurs in approximately 25 to 40% of lung cancer cases, in approximately 15 to 30% of breast cancer cases, and in certain percentages of other multiple cancer cases (Non Patent Literatures 2 and 3). As a matter of fact, it has been reported that brain metastasis occurs in approximately 20 to 30% of HER2-positive breast cancer cases (Non Patent Literature 4).

[0004]

Compounds having HER2 inhibitory activity, such as Lapatinib and Neratinib, have been approved as therapeutic agents against HER2-positive breast cancer. However, it has been reported that since all of these therapeutic agents are substrates of

p-gp or Bcrp, the brain penetration properties of these agents are limited in non-clinical tests (Non Patent Literature 5). In fact, in clinical tests using Lapatinib or Neratinib, sufficient effects of these agents could not be obtained against brain metastatic cancer (Non Patent Literatures 6, 7, 8, and 9).

From the viewpoint of the control of pathological conditions including brain metastasis nidus, it has been desired to develop a HER2 inhibitor having inhibitory activity against HER2 and also having brain penetration properties.

[0005]

One of HER2 mutations, HER2ex20ins mutation has been reported to be an activating mutation in lung cancer, etc. (Non Patent Literature 10), and regarding such HER2ex20ins mutation, multiple clinical trials have been carried out. However, under the current circumstances, a therapeutic method therefor has not yet been established. Therefore, it has been desired to develop a HER2 inhibitor having inhibitory activity against HER2ex20ins mutation.

[0006]

There are many reports on antitumor effects brought about by combinations of HER2 inhibitors and other antitumor agents. For example, combined use of trastuzumab with paclitaxel (Non Patent Literature 11), paclitaxel/platinum compound (Non Patent Literature 12), or the like has been reported. Also, combined use of lapatinib with capecitabine (Non Patent Literature 13), 5-FU (Non Patent Literature 14), S-1 (Non Patent Literature 15), or the like has been reported.

[0007]

EGFR (which is also referred to as "ErbB1") is a receptor tyrosine kinase belonging to the ErbB family and has been reported to contribute to cell growth or apoptosis inhibition by binding to epidermal growth factor (which is also referred to as "EGF"), mainly in epithelial tissues, among normal tissues (Non Patent Literature 16).

[0008]

EGFR is considered to be a proto-oncogene. It has been reported that EGFR gene amplification, overexpression, mutation and the like occur in various types of cancers. From non-clinical and clinical research data, it is considered that an activation of EGFR and downstream signals plays an important role in the survival and/or proliferation, etc. of cancer cells associated with the genetic abnormality, overexpression and the like of EGFR. For example, a mutation in exon 19 region of EGFR, which deletes amino acids at positions 746 to 750 (which is also referred to as "exon 19 deletion mutation"), and a mutation in exon 21 region, which substitutes an amino acid leucine at position 858 with arginine (which is also referred to as "L858R mutation") are considered

to contribute to the survival and/or proliferation of cancer cells by autophosphorylating EGFR in an EGF-independent manner and thereby inducing kinase activity (Non Patent Literature 17). It has been reported that these mutations are present in approximately 30 to 50% of non-small cell lung cancer cases in East Asia and approximately 10% of non-small cell lung cancer cases in Europe and the United States (Non Patent Literature 18).
[0009]

Accordingly, an inhibitor capable of regulating the kinase activity of EGFR is assumed to inhibit EGFR and downstream signals in cancer cells having EGFR gene amplification, overexpression and/or mutation, so as to exhibit antitumor effects on the cancer cells. Therefore, such an inhibitor is considered to be useful for the treatment, life-prolonging, or QOL improvement of cancer patients.
[0010]

Hence, a plurality of EGFR inhibitors have heretofore been researched and developed as anticancer agents and are used in the treatment of EGFR mutation-positive tumor. For example, drugs such as afatinib, gefitinib, and erlotinib have been approved as therapeutic agents for EGFR mutation-positive lung cancer having exon 19 deletion mutation or L858R mutation. Also, osimertinib has been approved as a therapeutic agent for EGFR mutation-positive lung cancer having exon 19 deletion mutation or L858R mutation as well as a mutation in exon 20 region, which substitutes an amino acid threonine at position 790 with methionine (which is also referred to as "T790M mutation").
[0011]

A mutation in exon 20 region, which insets one or more amino acids (which is also referred to as "exon 20 insertion mutation") is also considered as an activating mutation in lung cancer and the like (Non Patent Literature 19). It has been reported that cancer having such a mutation tends to be low sensitive to a plurality of existing EGFR inhibitors. For example, as for the clinical effect of afatinib on EGFR mutation-positive lung cancer, it has been reported that its effect on exon 20 insertion mutation tends to be much lower than that on exon 19 deletion mutation or L858R mutation (Non Patent Literature 20). Regarding lung cancer having exon 20 insertion mutation of EGFR, multiple clinical trials have been carried out. However, under the current circumstances, a therapeutic method therefor has not yet been established. Therefore, it has been desired to develop an EGFR inhibitor having inhibitory activity against exon 20 insertion mutation.

[0012]

As most of EGFR mutations have been reported on lung cancer, it has been

reported that brain metastasis occurs in approximately 25 to 40% of the cases.

[0013]

From the viewpoint of the control of pathological conditions including brain metastasis nidus, it has been desired to develop an EGFR inhibitor having inhibitory activity against EGFR mutations and also having brain penetration properties.

[0014]

Antitumor effects brought about by combinations of EGFR inhibitors and other antitumor agents have also been reported. For example, a combination of an EGFR inhibitor erlotinib with CDDP has been found to have a combinatorial effect (Non Patent Literature 21). A combination of erlotinib and RAD001 has also been reported to have a combinatorial effect (Non Patent Literature 22).

[0014a]

The discussion of documents, acts, materials, devices, articles and the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

[0014b]

Where the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components, or group thereof.

Citation List

Patent Literature

[0015]

Patent Literature 1: International Publication No. WO 2017/146116

Patent Literature 2: International Publication No. WO 2017/038838

Non Patent Literature

[0016]

Non Patent Literature 1: Cancer Treatment Reviews, 40, pp. 770-780 (2014)

Non Patent Literature 2: Current Oncology, 25, pp. S103-S114 (2018)

Non Patent Literature 3: Breast Cancer Research, 18(1), 8, pp. 1-9 (2016)

Non Patent Literature 4: Journal of Clinical Oncology, 28, pp. 3271-3277 (2010)

Non Patent Literature 5: Journal of Medicinal Chemistry, 59, pp. 10030-10066 (2016)

Non Patent Literature 6: Journal of Medicinal Chemistry, 26, pp. 2999-3005 (2008)
Non Patent Literature 7: Journal of Clinical Oncology, 26, pp. 1993-1999 (2008)
Non Patent Literature 8: Journal of Clinical Oncology, 28, pp. 1301-1307 (2010)
Non Patent Literature 9: Journal of Clinical Oncology, 34, pp. 945-952 (2016)
Non Patent Literature 10: Proc Natl Acad Sci USA., 106, pp. 474-479 (2009)
Non Patent Literature 11: N. Engl. J. Med., vol. 344, pp. 783-792 (2001)
Non Patent Literature 12: J. Natl. Cancer Inst., 96, pp. 739-749 (2004)
Non Patent Literature 13: Biologics., vol. 2, pp. 61-65 (2008)
Non Patent Literature 14: Oncol. Rep., vol. 27, pp. 1639-1645 (2012)
Non Patent Literature 15: Mol. Cancer Ther., vol. 9, pp. 1198-1207 (2010)
Non Patent Literature 16: Nat. Rev. Cancer., vol. 6, pp. 803-812 (2006)
Non Patent Literature 17: Nature Medicine., vol. 19, pp. 1389-1400 (2013)
Non Patent Literature 18: Nat. Rev. Cancer., vol. 7, pp. 169-181 (2007)
Non Patent Literature 19: Signal Transduct Target Ther., vol. 4: 5, pp. 1-10 (2019)
Non Patent Literature 20: Lancet Oncol. vol. 16, pp. 830-838 (2015)
Non Patent Literature 21: Neoplasia. vol. 17, pp. 190-200 (2015)
Non Patent Literature 22: Clin Cancer Res., vol. 13, pp. S4628-4631 (2007)

Summary of Invention

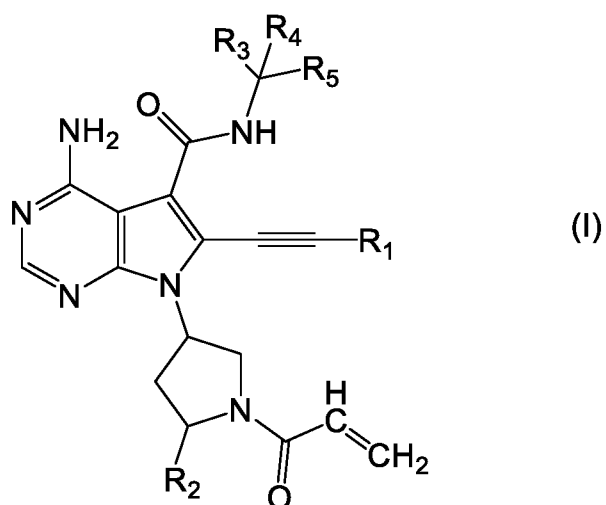
[0017]

An aspect of the present invention is to provide a method for treating tumor using a pyrimidine compound or a salt thereof and other antitumor agent.

[0018]

Specifically, one aspect of the present invention provides the following [1] to [17]:

[1] An antitumor agent for combined administration with other antitumor agent, the antitumor agent comprising a pyrimidine compound represented by the following formula (I), or a salt thereof:



wherein R_1 represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R_2 represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R_3 represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine

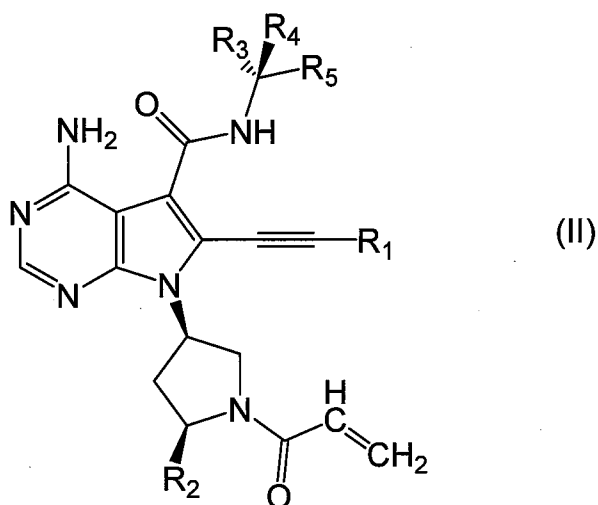
atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

[0019]

[2] The antitumor agent according to [1], wherein the pyrimidine compound is a compound represented by the following formula (II):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from the group consisting of fluorine atoms and chlorine atoms.

[0020]

[3] The antitumor agent according to [1] or [2], wherein the pyrimidine compound is represented by the formula (I) or (II) wherein

R₁ is a methyl group, an ethyl group, an isopropyl group, a tert-butyl group, a 1-methyl-1-methoxyethyl group, or a cyclopropyl group;

R₂ is a methyl group, an ethyl group, a methoxymethyl group, or an ethoxymethyl group;

R₃ is a methyl group, an ethyl group, or a trifluoromethyl group;

R₄ is a hydrogen atom or a methyl group; and

R₅ is a phenyl group, a 2-fluorophenyl group, a 3-chlorophenyl group, a 2,3-difluorophenyl group, a 2,4-difluorophenyl group, or a 3,5-difluorophenyl group.

[0021]

[4] The antitumor agent according to any of [1] to [3], wherein the pyrimidine compound is represented by the formula (I) or (II) wherein

R₁ is a methyl group, a tert-butyl group, or a cyclopropyl group;

R₂ is a methyl group, an ethyl group, or a methoxymethyl group;

R₃ is a methyl group;

R₄ is a hydrogen atom; and

R₅ is a phenyl group.

[0022]

[5] The antitumor agent according to any of [1] to [4], wherein the pyrimidine compound is a compound selected from the following (1) to (3):

(1) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,

(2) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide, and

(3) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(3,3-dimethylbut-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide.

[0023]

[6] The antitumor agent according to any of [1] to [5], wherein the other antitumor agent is at least one agent selected from antimetabolites, molecular targeting drugs, platinum drugs and alkaloid drugs.

[0024]

[7] The antitumor agent according to any of [1] to [6], wherein the other antitumor agent is at least one agent selected from 5-fluorouracil (5-FU), trifluridine, gemcitabine, capecitabine, trastuzumab, pertuzumab, trastuzumab emtansine, AZD8055, everolimus, dactolisib, buparlisib, taselisib, palbociclib, fulvestrant, cisplatin and paclitaxel.

[0025]

[8] The antitumor agent according to any of [1] to [7] for the treatment of tumor.

[0026]

[9] The antitumor agent according to any of [1] to [8], wherein the pyrimidine compound or the salt thereof is administered to a tumor patient given the other antitumor agent or a tumor patient to be given the other antitumor agent.

[0027]

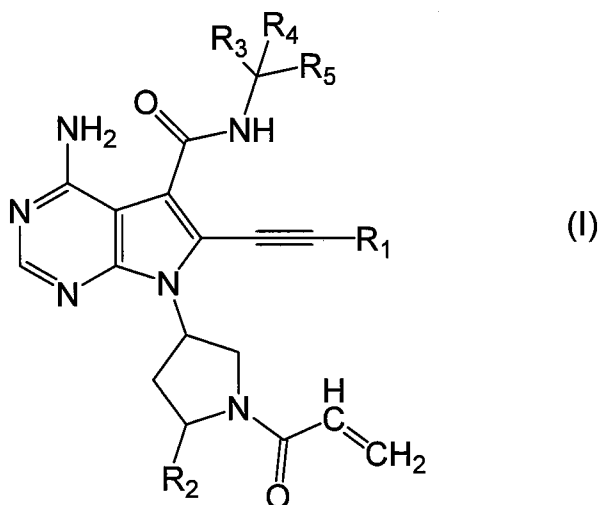
[10] The antitumor agent according to any of [1] to [9] for oral administration.

[0028]

[11] A pharmaceutical combination of a pyrimidine compound or a salt thereof and other antitumor agent, wherein

the pyrimidine compound is a compound represented by the following formula

(I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

[0029]

[12] The pharmaceutical combination according to [11] for use in the treatment of tumor, wherein the pyrimidine compound or the salt thereof and the other antitumor agent are administered concurrently, sequentially, or at an interval.

[12a] The pharmaceutical combination according to [11] or [12], wherein the pyrimidine compound is a compound according to any of [2] to [5].

[12b] The pharmaceutical combination according to [11] or [12], wherein the other antitumor agent is one described in [6] or [7].

[12c] The pharmaceutical combination according to [11], [12], [12a] or [12b], wherein the pyrimidine compound or the salt thereof is orally administered.

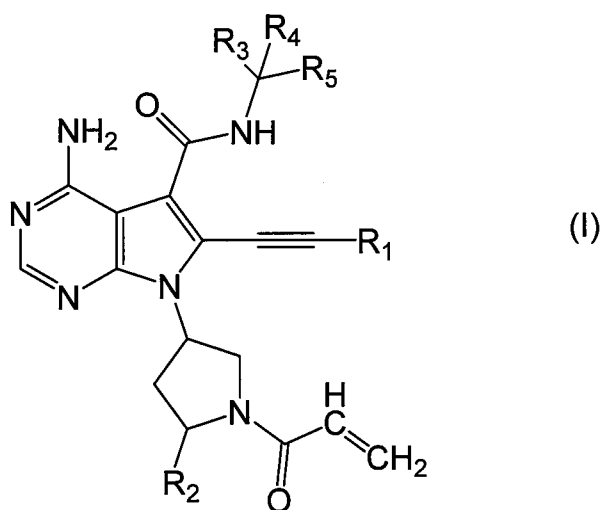
[0030]

[13] A kit preparation comprising an antitumor agent according to any of [1] to [10] or a pharmaceutical combination according to [11] or [12], and an instruction stating that the pyrimidine compound or the salt thereof and the other antitumor agent are combined-administered.

[0031]

[14] Use of a pyrimidine compound or a salt thereof for the production of a medicament that is used in combination with other antitumor agent in the treatment of tumor, wherein

the pyrimidine compound is a compound represented by the following formula (I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

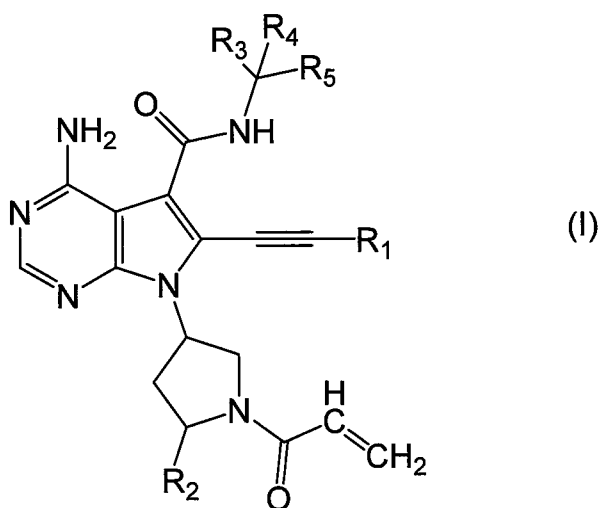
[14a] The use of a pyrimidine compound or a salt thereof according to [14], wherein the pyrimidine compound is a compound according to any of [2] to [5].

[14b] The use of a pyrimidine compound or a salt thereof according to [14] or [14a], wherein the other antitumor agent is one described in [6] or [7].

[14c] The use of a pyrimidine compound or a salt thereof according to [14], [14a] or [14b], wherein the pyrimidine compound or the salt thereof is orally administered.

[0032]

[15] An antitumor effect potentiator for potentiating the antitumor effect of other antitumor agent, the antitumor effect potentiator comprising a pyrimidine compound represented by the following formula (I), or a salt thereof:



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

[0033]

[16] A method for treating tumor, comprising administering an effective amount of an antitumor agent according to any of [1] to [10] and other antitumor agent or a pharmaceutical combination according to [11] or [12] to a patient in need thereof.

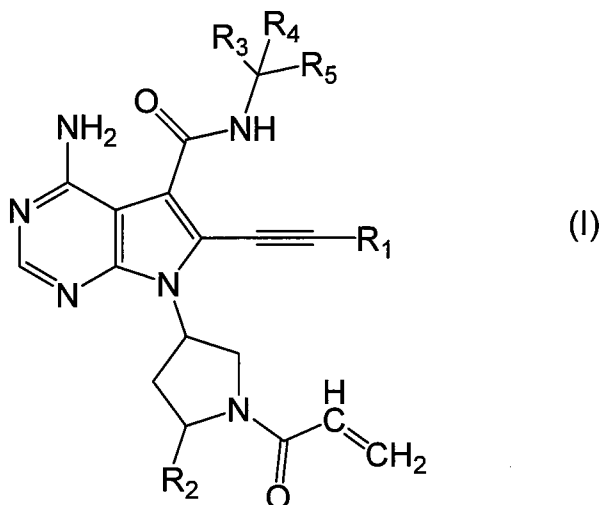
[0034]

[17] A method for treating tumor by combined use with other antitumor agent, comprising administering an effective amount of a pyrimidine compound or a salt thereof

to a patient in need thereof, wherein

the pyrimidine compound is a compound represented by the following formula

(I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

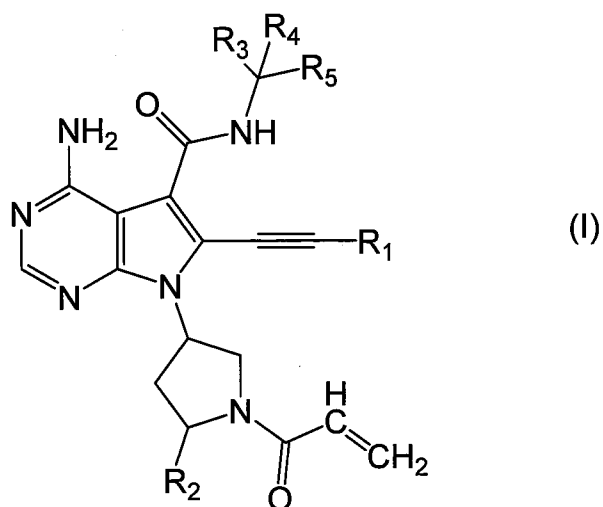
R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

[18] A pyrimidine compound or a salt thereof for use in a method for treating tumor by combined use with other antitumor agent, wherein the pyrimidine compound is a compound represented by the following formula (I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

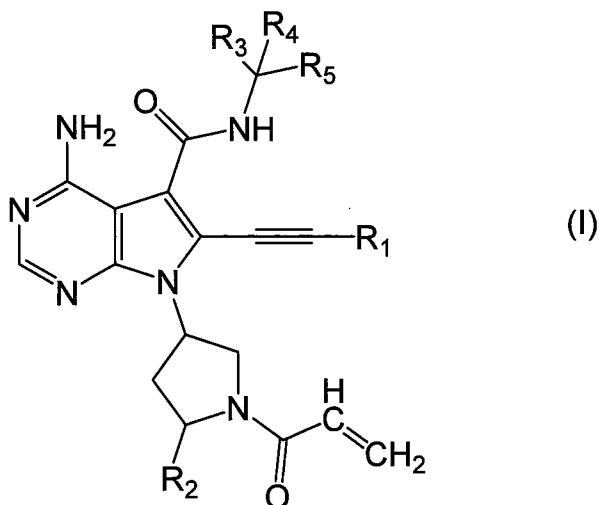
R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

[19] Use of a pyrimidine compound or a salt thereof for treating tumor by combined use with other antitumor agent, wherein the pyrimidine compound is a compound represented by the following formula (I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy

group as a substituent, or a C3-C4 cycloalkyl group;

R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

[20] The use according to [14] or [19], the antitumor effect potentiator according to [15], the method according to [17], or the pyrimidine compound of the salt thereof according to [18], wherein the pyrimidine compound is a compound according to any of [2] to [5].

[21] The use according to [14], [19], or [20], the antitumor effect potentiator according to [15] or [20], the method according to [17] or [20], or the pyrimidine compound of the salt thereof according to [18] or [20], wherein the other antitumor agent is one described in [6] or [7].

[22] The use according to [14], [19], [20] or [21], the antitumor effect potentiator according to [15], [20] or [21], the method according to [17] , [20] or [21], or the pyrimidine compound of the salt thereof according to [18] , [20] or [21], wherein the pyrimidine compound or the salt thereof is orally administered.

[0035]

The present invention also relates to the following aspects:

A pharmaceutical composition for the treatment of tumor, comprising a pyrimidine compound represented by the formula (I) or (II) or a salt thereof and other antitumor agent.

A pyrimidine compound represented by the formula (I) or (II) or a salt thereof for use in the treatment of tumor involving combined use with other antitumor agent.

Use of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof for the treatment of tumor involving combined use with other antitumor agent.

Other antitumor agent for use in the treatment of tumor involving combined use with a pyrimidine compound represented by the formula (I) or (II) or a salt thereof.

Use of other antitumor agent for the treatment of tumor involving combined use with a pyrimidine compound represented by the formula (I) or (II) or a salt thereof.

Use of other antitumor agent for the production of a medicament that is used in combination with a pyrimidine compound or a salt thereof in the treatment of tumor.

Use of a combination of a pyrimidine compound or a salt thereof and other antitumor agent for the production of a medicament in the treatment of tumor.

A pyrimidine compound represented by the formula (I) or (II) or a salt thereof for potentiating the antitumor effect of other antitumor agent.

Use of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof for potentiating the antitumor effect of other antitumor agent.

Other antitumor agent for potentiating the antitumor effect of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof.

Use of other antitumor agent for potentiating the antitumor effect of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof.

Use of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof for the production of an antitumor effect potentiator of other antitumor agent.

Use of other antitumor agent for the production of an antitumor effect potentiator of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof.

A method for treating tumor, comprising the step of administering a therapeutically effective amount of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof and other antitumor agent in combination to a patient.

A method for treating tumor, comprising the step of administering a therapeutically effective amount of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof to a tumor patient given other antitumor agent.

A method for treating tumor, comprising the step of administering a therapeutically effective amount of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof to a tumor patient to be given (scheduled to be given) other antitumor agent.

A method for treating tumor or a method for potentiating an antitumor effect, comprising the step of administering a therapeutically effective amount of other antitumor agent to a tumor patient given a pyrimidine compound represented by the formula (I) or (II) or a salt thereof.

A method for treating tumor or a method for potentiating an antitumor effect, comprising the step of administering a therapeutically effective amount of other antitumor agent to a tumor patient to be given (scheduled to be given) a pyrimidine compound represented by the formula (I) or (II) or a salt thereof.

A method for potentiating an antitumor effect, comprising the step of administering a therapeutically effective amount of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof to a tumor patient given other antitumor agent.

A product comprising a pyrimidine compound represented by the formula (I) or

(II) or a salt thereof and other antitumor agent as a combination product for concurrent, sequential, or staggered use in treating tumor.

A combination of a pyrimidine compound represented by the formula (I) or (II) or a salt thereof and other antitumor agent for concurrent, sequential, or staggered use in the treatment of tumor.

[0036]

In one embodiment of the aspects mentioned above, the tumor is malignant tumor having HER2 overexpression, HER2 gene amplification, or a HER2 mutation, and the other antitumor agent is at least one agent selected from antimetabolites, Her2 inhibitors, PI3K/AKT/mTOR inhibitors, CDK4/6 inhibitors, estrogen receptor antagonists, platinum drugs, and vegetable alkaloid drugs.

In one embodiment of the aspects mentioned above, the tumor is malignant tumor having EGFR overexpression, EGFR gene amplification, or an EGFR mutation, and the other antitumor agent is at least one agent selected from antimetabolites, PI3K/AKT/mTOR inhibitors, CDK4/6 inhibitors, estrogen receptor antagonists, platinum drugs, and vegetable alkaloid drugs.

[0037]

In one embodiment of the aspects mentioned above, the tumor is HER2-positive tumor, and the other antitumor agent is at least one agent selected from antimetabolites, Her2 inhibitors, PI3K/AKT/mTOR inhibitors, CDK4/6 inhibitors, estrogen receptor antagonists, platinum drugs, and vegetable alkaloid drugs.

In one embodiment of the aspects mentioned above, the tumor is EGFR-positive tumor, and the other antitumor agent is at least one agent selected from antimetabolites, PI3K/AKT/mTOR inhibitors, CDK4/6 inhibitors, estrogen receptor antagonists, platinum drugs, and vegetable alkaloid drugs.

[0038]

The present invention provides a novel method for treating tumor using a pyrimidine compound or a salt thereof and other antitumor agent.

The antitumor agent of the present invention is capable of performing the treatment of tumor that exerts a high antitumor effect (particularly, a cytoreductive effect and a tumor growth delaying effect (life extending effect)) while preventing the development of side effects.

Brief Description of Drawings

[0039]

[Figure 1] Figure 1 shows the antitumor effects of the compound of Example 2 against

models involving direct brain transplantation of the Luciferase gene-introduced HER2 expressing cell line (NCI-N87-luc).

[Figure 2] Figure 2 shows the antitumor effects of the compound of Example 11 against models involving direct brain transplantation of the Luciferase gene-introduced HER2 expressing cell line (NCI-N87-luc).

[Figure 3] Figure 3 shows the antitumor effects of the compound of Example 12 against models involving direct brain transplantation of the Luciferase gene-introduced HER2 expressing cell line (NCI-N87-luc).

[Figure 4] Figure 4 shows the body weight reduction percentage of models involving direct brain transplantation of the Luciferase gene-introduced HER2 expressing cell line (NCI-N87-luc) caused by the compound of Example 2.

[Figure 5] Figure 5 shows the body weight reduction percentage of models involving direct brain transplantation of the Luciferase gene-introduced HER2 expressing cell line (NCI-N87-luc) caused by the compound of Example 11.

[Figure 6] Figure 6 shows the body weight reduction percentage of models involving direct brain transplantation of the Luciferase gene-introduced HER2 expressing cell line (NCI-N87-luc) caused by the compound of Example 12.

[Figure 7] Figure 7 shows the antitumor effects of compounds of Example 2, 11 and 12 against models involving subcutaneous transplantation of the H1975-EGFRinsSVD cell line.

[Figure 8] Figure 8 shows the body weight change percentage of mice when the compounds of Examples 2, 11 and 12 were administered to the models involving subcutaneous transplantation of the H1975-EGFRinsSVD cell line.

[Figure 9] Figure 9 shows the antitumor effects of the compound of Example 11 against models involving direct brain transplantation of the Luciferase gene-introduced exon 20 insertion mutant EGFR expressing cell line (H1975-EGFRinsSVD-Luc).

[Figure 10] Figure 10 shows the survival rate of mice when the compound of Example 11 was administered to the models involving direct brain transplantation of the Luciferase gene-introduced exon 20 insertion mutant EGFR expressing cell line (H1975-EGFRinsSVD-Luc).

[Figure 11] Figure 11 shows the therapeutic effect of a combination of a compound of Example 11 and trastuzumab on human stomach cancer-derived tumor cells.

[Figure 12] Figure 12 shows the therapeutic effect of a combination of the compound of Example 11, trastuzumab (T-mab), and pertuzumab (P-mab) on human stomach cancer-derived tumor cells.

[Figure 13] Figure 13 shows the therapeutic effect of a combination of the compound of

Example 11 and trastuzumab emtansine on human stomach cancer-derived tumor cells.

[Figure 14] Figure 14 shows the therapeutic effect of a combination of the compound of Example 11 and capecitabine on human stomach cancer-derived tumor cells.

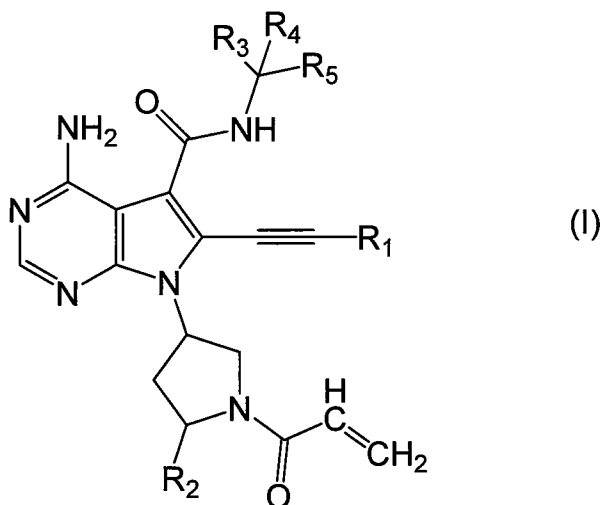
[Figure 15] Figure 15 shows the therapeutic effect of a combination of the compound of Example 11 and capecitabine on human stomach cancer-derived tumor cells.

Description of Embodiments

[0040]

One embodiment of the present invention relates to a combination of a pyrimidine compound represented by the formula (I) having pyrimidine as a basic skeleton, or a salt thereof and another compound having an antitumor effect (other antitumor agent). Combined use of the pyrimidine compound or the salt thereof and the other antitumor agent is capable of potentiating an antitumor effect as compared with use of each alone and is capable of preventing the enhancement of toxicity and the development of side effects. Thus, the combination is capable of performing the treatment of tumor that exerts an excellent antitumor effect while preventing the development of side effects.

In the present invention, a compound that brings about an excellent synergistic effect when used in combination with other antitumor agent is a pyrimidine compound represented by the following formula (I), or a salt thereof:



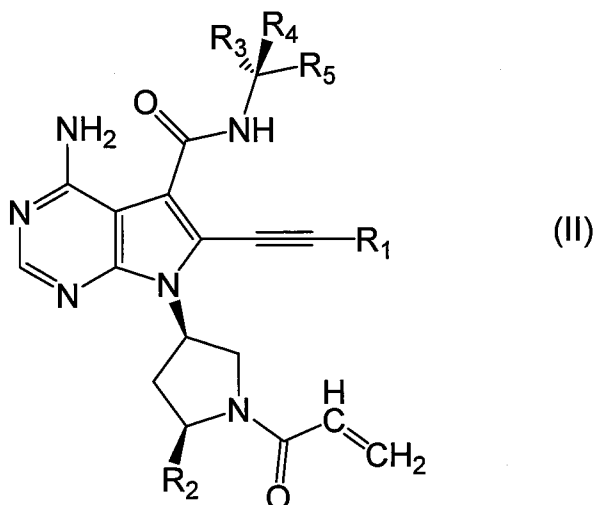
[0041]

wherein R₁ to R₅ are as defined above.

[0042]

In one preferred embodiment of the present invention, a compound that brings about an excellent synergistic effect when used in combination with other antitumor agent

is a compound represented by the following formula (II), or a salt thereof:



[0043]

wherein R₁ to R₅ are as defined above.

[0044]

The compound represented by the above formula (I) or formula (II) of the present invention is a compound having pyrrolo[2,3-d]pyrimidine as a basic structure, and this is a novel compound described in none of the aforementioned prior art publications, etc. Hereinafter, the compound represented by the above formula (I) or formula (II) mentioned above is also referred to as "the pyrimidine compound of the present invention or a salt thereof".

[0045]

In the present description, specific examples of the "halogen atom" may include a chlorine atom, a bromine atom, a fluorine atom, and an iodine atom. Among these, a chlorine atom and a fluorine atom are preferable, and a fluorine atom is more preferable.

[0046]

In the present description, the "alkyl group" means a linear or branched saturated hydrocarbon group. Specific examples of the alkyl group may include a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, and a hexyl group. Among these, a linear or branched alkyl group containing 1 to 4 carbon atoms is preferable, and a methyl group and a tert-butyl group are more preferable.

[0047]

In the present description, the "haloalkyl group" means a linear or branched saturated hydrocarbon group, in which one to all hydrogen atoms are substituted with the

above-described halogen atoms. Specific examples of the haloalkyl group may include a monofluoromethyl group, a difluoromethyl group, a trifluoromethyl group, a 1-fluoroethyl group, a 2-fluoroethyl group, a 1,1-difluoroethyl group, a 1,2-difluoroethyl group, a 2,2-difluoroethyl group, a 2,2,2-trifluoroethyl group, a monochloromethyl group, a dichloromethyl group, a trichloromethyl group, a 1-chloroethyl group, a 2-chloroethyl group, and a 1,1-dichloroethyl group. Among these, a linear or branched saturated hydrocarbon group containing 1 to 6 carbon atoms, in which 1 to 3 hydrogen atoms are substituted with the above-described halogen atoms, is preferable, and a monofluoromethyl group is more preferable.

[0048]

In the present description, the "cycloalkyl group" means a monocyclic or polycyclic saturated hydrocarbon group containing 3 to 7 carbon atoms. Specific examples of the cycloalkyl group may include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. Among these, a cyclopropyl group and a cyclobutyl group are preferable.

[0049]

In the present description, the "aromatic hydrocarbon group" means a cyclic substituent consisting of carbon and hydrogen, having an unsaturated bond, in which $4e + 2$ (wherein e represents an integer of 1 or greater) electrons are contained in the cyclic π electron system.

[0050]

In the present description, the "C6-C14 aromatic hydrocarbon group" means a monocyclic or polycyclic aromatic hydrocarbon group containing 6 to 14 carbon atoms. Specific examples of the C6-C14 aromatic hydrocarbon group may include a phenyl group, a naphthyl group, a tetrahydronaphthyl group, and an anthracenyl group. Among these, a phenyl group is preferable.

[0051]

In the present description, the "aralkyl group" means the above-described alkyl group substituted with the above-described aromatic hydrocarbon group. Specific examples of the aralkyl group may include C7-C16 aralkyl groups such as a benzyl group, a phenylethyl group, a phenylpropyl group, a naphthylmethyl group, and a naphthylethyl group. Among these, a benzyl group is preferable.

[0052]

In the present description, the "unsaturated hydrocarbon group" means a linear or branched hydrocarbon group containing 2 to 6 carbon atoms, which comprises at least one carbon-carbon double bond or triple bond. Specific examples of the unsaturated

hydrocarbon group may include a vinyl group, an allyl group, a methylvinyl group, a propenyl group, a butenyl group, a pentenyl group, a hexenyl group, an ethynyl group, and a 2-propynyl group. Among these, a vinyl group, an allyl group, and a 1-propenyl group are preferable.

[0053]

In the present description, the "alkenyl group" means a linear or branched hydrocarbon group containing 2 to 6 carbon atoms, which comprises at least one carbon-carbon double bond. Specific examples of the alkenyl group may include C2-C6 alkenyl groups, such as a vinyl group, an allyl group, a 2-methyl-2-propenyl group, an isopropenyl group, a 1-, 2- or 3-butenyl group, a 2-, 3- or 4-pentenyl group, a 2-methyl-2-butenyl group, a 3-methyl-2-butenyl group, and a 5-hexenyl group. Among these, a vinyl group, an allyl group, a 1-propenyl group, and a 2-methyl-2-propenyl group are preferable.

[0054]

In the present description, the "alkynyl group" means a linear or branched unsaturated hydrocarbon group having at least one triple bond (for example, 1 or 2, and preferably 1 triple bond). Specific examples of the alkynyl group may include C2-C6 alkynyl groups such as an ethynyl group, a 1- or 2-propynyl group, a 1-, 2- or 3-butylnyl group, and a 1-methyl-2-propynyl group. Among these, an ethynyl group and a 2-propynyl group are preferable.

[0055]

In the present description, the "C3-C10 cyclic unsaturated hydrocarbon group" means a monocyclic or polycyclic hydrocarbon group containing 3 to 10 carbon atoms, which comprises at least one carbon-carbon double bond. Specific examples of the C3-C10 cyclic unsaturated hydrocarbon group may include a cyclopropenyl group, a cyclobutenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a cyclooctenyl group, and a cyclononyl group. Among these, a monocyclic or polycyclic hydrocarbon group containing 3 to 7 carbon atoms, which comprises at least one carbon-carbon double bond, is preferable, and a cyclopropenyl group is more preferable.

[0056]

In the present description, the "alkoxy group" means an oxy group having the above-described alkyl group. Specific examples of the alkoxy group may include C1-C6 alkoxy groups such as a methoxy group, an ethoxy group, an n-propoxy group, an isopropoxy group, an n-butoxy group, an isobutoxy group, a sec-butoxy group, a tert-butoxy group, a pentyloxy group, an isopentyloxy group, and a hexyloxy group. Among

these, a methoxy group and an ethoxy group are preferable, and a methoxy group is more preferable.

[0057]

In the present description, the "haloalkoxy group" may include the above-described alkoxy group having at least one halogen atom (preferably 1 to 13, and more preferably 1 to 3 halogen atoms). Specific examples of the haloalkoxy group may include C1-C6 haloalkoxy groups such as a fluoromethoxy group, a difluoromethoxy group, a trifluoromethoxy group, a trichloromethoxy group, a fluoroethoxy group, a 1,1,1-trifluoroethoxy group, a monofluoro-n-propoxy group, a perfluoro-n-propoxy group, and a perfluoro-isopropoxy group.

[0058]

In the present description, the "cycloalkoxy group" means an oxy group having the above-described cycloalkyl group. Specific examples of the cycloalkoxy group may include C3-C7 cycloalkoxy groups such as a cyclopropoxy group, a cyclobutoxy group, a cyclopentyloxy group, a cyclohexyloxy group, and a cycloheptyloxy group. Among these, a cyclobutoxy group, a cyclopentyloxy group, and a cyclohexyloxy group are preferable.

[0059]

In the present description, the "aralkyloxy group" means an oxy group having the above-described aralkyl group. Specific examples of the aralkyloxy group may include C7-C20 aralkyloxy groups such as a benzyloxy group, a phenethyloxy group, a naphthylmethyloxy group, and a fluorenylmethyloxy group. Among these, a benzyloxy group is preferable.

[0060]

In the present description, the "alkylthio group" means a thioxy group having the above-described alkyl group. Specific examples of the alkylthio group may include C1-C6 alkylthio groups such as a methylthio group, an ethylthio group, an n-propylthio group, an isopropylthio group, an n-butylthio group, an isobutylthio group, a tert-butylthio group, an n-pentylthio group, an isopentylthio group, and a hexylthio group. Among these, a methylthio group, an ethylthio group, and an n-propylthio group are preferable.

[0061]

In the present description, the "alkoxyalkyl group" means the above-described alkyl group having at least one of the above-described alkoxy groups. Specific examples of the alkoxyalkyl group may include C1-C6 alkoxy-C1-C6 alkyl groups such as a methoxymethyl group, an ethoxyethyl group, a methoxyethyl group, and a methoxypropyl group.

[0062]

In the present description, the "alkylamino group" means an amino group in which 1 or 2 hydrogen atoms are substituted with a linear or branched hydrocarbon group(s) containing 1 to 6 carbon atoms. Specific examples of the alkylamino group may include a methylamino group, an ethylamino group, a dimethylamino group, a diethylamino group, and an ethylmethylamino group. Among these, preferable is an amino group in which 1 or 2 hydrogen atoms are substituted with a linear or branched hydrocarbon group containing 1 to 3 carbon atoms.

[0063]

In the present description, the "monoalkylamino group" means an amino group in which one hydrogen atom is substituted with a linear or branched hydrocarbon group. Specific examples of the monoalkylamino group may include a methylamino group, an ethylamino group, an n-propylamino group, an isopropylamino group, an n-butylamino group, an isobutylamino group, a sec-butylamino group, a tert-butylamino group, a pentylamino group, and a hexylamino group. Among these, preferable is an amino group in which one hydrogen atom is substituted with a linear or branched hydrocarbon group containing 1 to 3 carbon atoms.

[0064]

In the present description, the "dialkylamino group" means an amino group in which two hydrogen atoms are substituted with linear or branched hydrocarbon groups containing 1 to 6 carbon atoms. Specific examples of the dialkylamino group may include a dimethylamino group, a diethylamino group, and an ethylmethylamino group. Among these, an amino group in which two hydrogen atoms are substituted with linear or branched hydrocarbon groups containing 1 to 3 carbon atoms is preferable, and a dimethylamino group is more preferable.

[0065]

In the present description, the "acyl group" means a formyl group in which a hydrogen atom is substituted with a linear or branched hydrocarbon group. Specific examples of the acyl group may include an acetyl group, an n-propanoyl group, an isopropanoyl group, an n-butyloyl group, and a tert-butyloyl group. Among these, a formyl group in which a hydrogen atom is substituted with a linear or branched hydrocarbon group containing 1 to 3 carbon atoms is preferable, and an acetyl group is more preferable.

[0066]

In the present description, the "acyloxy group" means an oxy group having the above-described acyl group. Specific examples of the acyloxy group may include an

alkylcarbonyloxy group and an arylcarbonyloxy group. Among these, an oxy group in which a hydrogen atom of formyl group is substituted with a linear or branched hydrocarbon group containing 1 to 3 carbon atoms is preferable, and an alkylcarbonyloxy group is more preferable.

[0067]

In the present description, the "alkoxycarbonyl group" means a carbonyl group having the above-described alkoxy group. Specific examples of the alkoxycarbonyl group may include (C1-C6alkoxy)carbonyl groups such as a methoxycarbonyl group, an ethoxycarbonyl group, a propoxycarbonyl group, an isopropoxycarbonyl group, a butoxycarbonyl group, an isobutoxycarbonyl group, a tert-butoxycarbonyl group, a pentyloxycarbonyl group, an isopentyloxycarbonyl group, and a hexyloxycarbonyl group. Among these, a tert-butoxycarbonyl group is preferable.

[0068]

In the present description, the "aralkyloxycarbonyl group" means a carbonyl group having the above-described aralkyloxy. Specific examples of the aralkyloxycarbonyl group may include (C6-C20 aralkyl)oxycarbonyl groups such as a benzyloxycarbonyl group, a phenethyloxycarbonyl group, a naphthylmethyloxycarbonyl group, and a fluorenylmethyloxycarbonyl group. Among these, a benzyloxycarbonyl group is preferable.

[0069]

In the present description, the "saturated heterocyclic group" means a monocyclic or polycyclic saturated heterocyclic group having at least one heteroatom (preferably 1 to 5, and more preferably 1 to 3 heteroatoms) selected from nitrogen atoms, oxygen atoms, and sulfur atoms. Specific examples of the saturated heterocyclic group may include an aziridinyl group, an azetidiny group, an imidazolidinyl group, a morpholino group, a pyrrolidinyl group, a piperidinyl group, a piperazinyl group, a tetrahydrofuranyl group, a tetrahydropyranyl group, a tetrahydrothiophenyl group, a thiazolidinyl group, and an oxazolidinyl group. Among these, an azetidiny group, a pyrrolidinyl group, and a piperidinyl group are preferable, and an azetidiny group and a pyrrolidinyl group are more preferable.

[0070]

In the present description, the "unsaturated heterocyclic group" means a monocyclic or polycyclic completely unsaturated or partially unsaturated heterocyclic group having at least one heteroatom (preferably 1 to 5, and more preferably 1 to 3 heteroatoms) selected from nitrogen atoms, oxygen atoms, and sulfur atoms. Specific examples of the unsaturated heterocyclic group may include an imidazolyl group, a

thienyl group, a pyrrolyl group, an oxazolyl group, an isoxazolyl group, a thiazolyl group, an isothiazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazolyl group, a triazolyl group, a tetrazolyl group, a pyridyl group, a pyrazyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a triazolopyridyl group, a benzimidazolyl group, a benzoxazolyl group, a benzothiazolyl group, a benzothienyl group, a furanyl group, a benzofuranyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a quinazolinyl group, a quinoxalyl group, a methylenedioxyphenyl group, an ethylenedioxyphenyl group, and a dihydrobenzofuranyl group. Among these, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isoxazolyl group, and a furanyl group are preferable; an imidazolyl group, a pyrazolyl group, and a thiazolyl group are more preferable; and an imidazolyl group is most preferable.

[0071]

In the present description, the "saturated heterocyclic oxy group" means an oxy group having the above-described saturated heterocyclic group. Specific examples of the saturated heterocyclic oxy group may include a morpholinyl group, a 1-pyrrolidinyl group, a piperidinyl group, a piperazinyl group, a 4-methyl-1-piperazinyl group, a tetrahydrofuran group, a tetrahydropyran group, a tetrahydrothiophenyl group, a thiazolidyl group, and an oxazolidyl group. Among these, a 1-pyrrolidinyl group, a piperidinyl group, and a piperazinyl group are preferable.

[0072]

In the compound represented by the formula (I) or the formula (II) of the present invention, R₁ is a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group.

[0073]

The "C1-C4 alkoxy group" in the "C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent" represented by R₁ is preferably a methoxy group or an ethoxy group, and most preferably a methoxy group. Herein, the number of substituents is preferably 1 to 3, and most preferably 1. When the C1-C4 alkyl group has two or more substituents, the substituents may be identical to or different from each other.

[0074]

The "C1-C4 alkyl group" in the "C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent" represented by R₁ is preferably a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group, more preferably a methyl group, an ethyl group, an isopropyl group, or a tert-butyl group, and most

preferably a methyl group or a tert-butyl group.

[0075]

The "C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent" represented by R₁ is preferably a C1-C4 alkyl group having 1 to 3 methoxy groups as substituents, more preferably a methyl group, an ethyl group, an isopropyl group, a tert-butyl group, or a 1-methyl-1-methoxyethyl group, and most preferably a methyl group or a tert-butyl group.

[0076]

The "C3-C4 cycloalkyl group" represented by R₁ is preferably a cyclopropyl group or a cyclobutyl group, and most preferably a cyclopropyl group.

[0077]

R₁ is preferably a C1-C4 alkyl group optionally having 1 to 3 C1-C4 alkoxy groups as substituents, or a C3-C4 cycloalkyl group.

[0078]

R₁ is more preferably a C1-C4 alkyl group optionally having 1 to 3 methoxy groups as substituents, or a C3-C4 cycloalkyl group.

[0079]

R₁ is further preferably a methyl group, an ethyl group, an isopropyl group, a tert-butyl group, a 1-methyl-1-methoxyethyl group, or a cyclopropyl group.

[0080]

R₁ is most preferably a methyl group, a tert-butyl group, or a cyclopropyl group.

[0081]

In the compound represented by the formula (I) or the formula (II) of the present invention, R₂ is a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group.

[0082]

The "halogen atom" represented by R₂ is preferably a fluorine atom or a chlorine atom.

[0083]

The "C1-C4 alkoxy group" in the "C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s)" represented by R₂ is preferably a methoxy group or an ethoxy group, and most preferably a methoxy group.

[0084]

The "C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s)" represented by R₂ is preferably a methyl group,

an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group, and most preferably a methyl group.

[0085]

The "C1-C6 alkyl group" in the "C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s)" represented by R₂ is preferably a C1-C6 alkyl group optionally having 1 to 5 methoxy groups, ethoxy groups, or fluorine atoms as a substituent(s) (specifically, a methyl group, a methoxymethyl group, an ethoxymethyl group, a methoxyethyl group, an ethoxyethyl group, a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, etc.), more preferably a C1-C6 alkyl group, further preferably a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group, and most preferably a methyl group.

[0086]

The "C1-C6 alkoxy group" represented by R₂ is preferably a methoxy group or an ethoxy group, and most preferably a methoxy group.

[0087]

R₂ is preferably a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s). In one embodiment, R₂ is a C1-C6 alkyl group optionally having 1 to 5 methoxy groups, ethoxy groups, or fluorine atoms as a substituent(s). In another embodiment, R₂ is a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group (preferably a methyl group or an ethyl group, and more preferably a methyl group), each optionally having 1 to 5 methoxy groups, ethoxy groups, or fluorine atoms as a substituent(s).

[0088]

R₂ is more preferably a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups as a substituent(s). In one embodiment, R₂ is a C1-C6 alkyl group optionally having 1 to 5 methoxy groups or ethoxy groups as a substituent(s). In another embodiment, R₂ is a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group (preferably a methyl group or an ethyl group, and more preferably a methyl group) each optionally having 1 to 5 methoxy groups or ethoxy groups as a substituent(s). In a further embodiment, R₂ is a methyl group, an ethyl group, a methoxymethyl group, or an ethoxymethyl group.

[0089]

R₂ is even more preferably a C1-C6 alkyl group.

[0090]

R₂ is further preferably a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group.

R₂ is particularly preferably a methyl group or an ethyl group.

R₂ is most preferably a methyl group.

[0091]

In the compound represented by the formula (I) or the formula (II) of the present invention, R₃ is a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s).

[0092]

The "C1-C4 alkyl group" in the "C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s)" represented by R₃ is preferably a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group, more preferably a methyl group or an ethyl group, and most preferably a methyl group.

[0093]

The "C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s)" represented by R₃ is preferably a methyl group, a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, or an ethyl group, more preferably a methyl group, a trifluoromethyl group, or an ethyl group, and most preferably a methyl group.

[0094]

R₃ is preferably a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s).

[0095]

R₃ is more preferably a methyl group, a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, an ethyl group, a fluoroethyl group, a difluoroethyl group, a trifluoroethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group.

[0096]

R₃ is even more preferably a methyl group, a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, or an ethyl group.

[0097]

R₃ is further preferably a methyl group, a trifluoromethyl group, or an ethyl group.

R₃ is particularly preferably a methyl group or an ethyl group.

R₃ is most preferably a methyl group.

[0098]

In the compound represented by the formula (I) or the formula (II) of the present invention, R₄ is a hydrogen atom or a C1-C4 alkyl group.

[0099]

The "C1-C4 alkyl group" represented by R₄ is preferably a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group, more preferably a methyl group or an ethyl group, and most preferably a methyl group.

[0100]

R₄ is preferably a hydrogen atom, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group.

[0101]

R₄ is more preferably a hydrogen atom, a methyl group, or an ethyl group.

[0102]

R₄ is further preferably a hydrogen atom or a methyl group.

R₄ is most preferably a hydrogen atom.

[0103]

In the compound represented by the formula (I) or the formula (II) of the present invention, R₅ is a phenyl group optionally having 1 to 3 substituents selected from the group consisting of fluorine atoms and chlorine atoms.

[0104]

R₅ is preferably a phenyl group optionally having 1 or 2 substituents selected from the group consisting of fluorine atoms and chlorine atoms.

[0105]

R₅ is more preferably a phenyl group, a 2-fluorophenyl group, a 3-chlorophenyl group, a 2,3-difluorophenyl group, a 2,4-difluorophenyl group, or a 3,5-difluorophenyl group.

[0106]

R₅ is most preferably a phenyl group.

[0107]

The pyrimidine compound of the present invention is preferably the compound represented by the formula (I) or the formula (II), or a salt thereof, wherein, in the formula (I) or the formula (II),

R₁ is a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group,

R₂ is a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups as a substituent(s),

R₃ is a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s),

R₄ is a hydrogen atom or a C1-C4 alkyl group, and

R₅ is a phenyl group optionally having 1 or 2 substituents selected from the group

consisting of fluorine atoms and chlorine atoms.

[0108]

The compound of the present invention is more preferably the compound represented by the formula (I) or the formula (II), or a salt thereof, wherein, in the formula (I) or the formula (II),

R₁ is a methyl group, an ethyl group, an n-propyl group, an isopropyl group, a tert-butyl group, a 1-methyl-1-methoxyethyl group, a cyclopropyl group, or a cyclobutyl group,

R₂ is a methyl group, an ethyl group, an n-propyl group, a tert-butyl group, a methoxymethyl group or an ethoxymethyl group,

R₃ is a methyl group, a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, an ethyl group, a fluoroethyl group, a difluoroethyl group, a trifluoroethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group,

R₄ is a hydrogen atom, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, or a tert-butyl group, and

R₅ is a phenyl group, a 2-fluorophenyl group, a 3-fluorophenyl group, a 2,4-difluorophenyl group, a 2,3-difluorophenyl group, a 3,5-difluorophenyl group, a 2-chlorophenyl group, a 3-chlorophenyl group, a 2,4-dichlorophenyl group, or a 3,5-dichlorophenyl group.

[0109]

The compound of the present invention is even more preferably the compound represented by the formula (II), or a salt thereof, wherein, in the formula (II),

R₁ is a methyl group, an ethyl group, an isopropyl group, a tert-butyl group, a 1-methyl-1-methoxyethyl group, or a cyclopropyl group,

R₂ is a methyl group, an ethyl group, a methoxymethyl group or an ethoxymethyl group,

R₃ is a methyl group, a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, or an ethyl group,

R₄ is a hydrogen atom, a methyl group, or an ethyl group, and

R₅ is a phenyl group, a 2-fluorophenyl group, a 3-chlorophenyl group, a 2,3-difluorophenyl group, a 2,4-difluorophenyl group, or a 3,5-difluorophenyl group.

[0110]

The compound of the present invention is further preferably the compound represented by the formula (II), or a salt thereof, wherein, in the formula (II),

R₁ is a methyl group, a tert-butyl group, or a cyclopropyl group,

R₂ is a methyl group, an ethyl group, a methoxymethyl group or an ethoxymethyl

group,

R₃ is a methyl group, a trifluoromethyl group, or an ethyl group,

R₄ is a hydrogen atom or a methyl group, and

R₅ is a phenyl group.

[0111]

The compound of the present invention is further preferably the compound represented by the formula (II), or a salt thereof, wherein, in the formula (II),

R₁ is a methyl group, a tert-butyl group, or a cyclopropyl group,

R₂ is a methyl group, an ethyl group, or a methoxymethyl group,

R₃ is a methyl group,

R₄ is a hydrogen atom, and

R₅ is a phenyl group.

[0112]

The compound of the present invention is particularly preferably the compound represented by the formula (II), or a salt thereof, wherein, in the formula (II),

R₁ is a methyl group, a tert-butyl group, or a cyclopropyl group,

R₂ is a methyl group,

R₃ is a methyl group,

R₄ is a hydrogen atom, and

R₅ is a phenyl group.

[0113]

Specific examples of the compound represented by the formula (I) or the formula (II) may include compounds produced in the following Examples, but are not limited thereto.

One embodiment of the present invention relates to a compound selected from the following (1) to (19), or a salt thereof. One embodiment of the present invention relates to a compound selected from the following (1) to (15), or a salt thereof.

- (1) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
- (2) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
- (3) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(3,3-dimethylbut-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
- (4) 7-(R)-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-(3,5-difluorophenyl)ethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
- (5) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(2-phenylpropan-2-yl)-

6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (6) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylpropyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (7) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(2-(2-fluorophenyl)propan-2-yl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (8) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-(3-chlorophenyl)ethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (9) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-(2,4-difluorophenyl)ethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (10) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(prop-1-yn-1-yl)-N-((S)-2,2,2-trifluoro-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (11) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-(2-phenylpropan-2-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (12) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-(2,3-difluorophenyl)ethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (13) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(3-methoxy-3-methylbut-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (14) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(but-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (15) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(2-(2-fluorophenyl)propan-2-yl)-6-(3-methylbut-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (16) 7-((3R,5S)-1-acryloyl-5-ethylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (17) 7-((3R,5S)-1-acryloyl-5-ethylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
 (18) 7-((3R,5R)-1-acryloyl-5-(methoxymethyl)pyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide, and
 (19) 7-((3R,5R)-1-acryloyl-5-(ethoxymethyl)pyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide.

[0114]

A preferred example of the compound represented by the formula (I) or the

formula (II) may be a compound selected from the following (1) to (3), or a salt thereof.

- (1) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,
- (2) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide, and
- (3) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(3,3-dimethylbut-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide.

[0115]

The most preferred pyrimidine compound of the present invention is 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide.

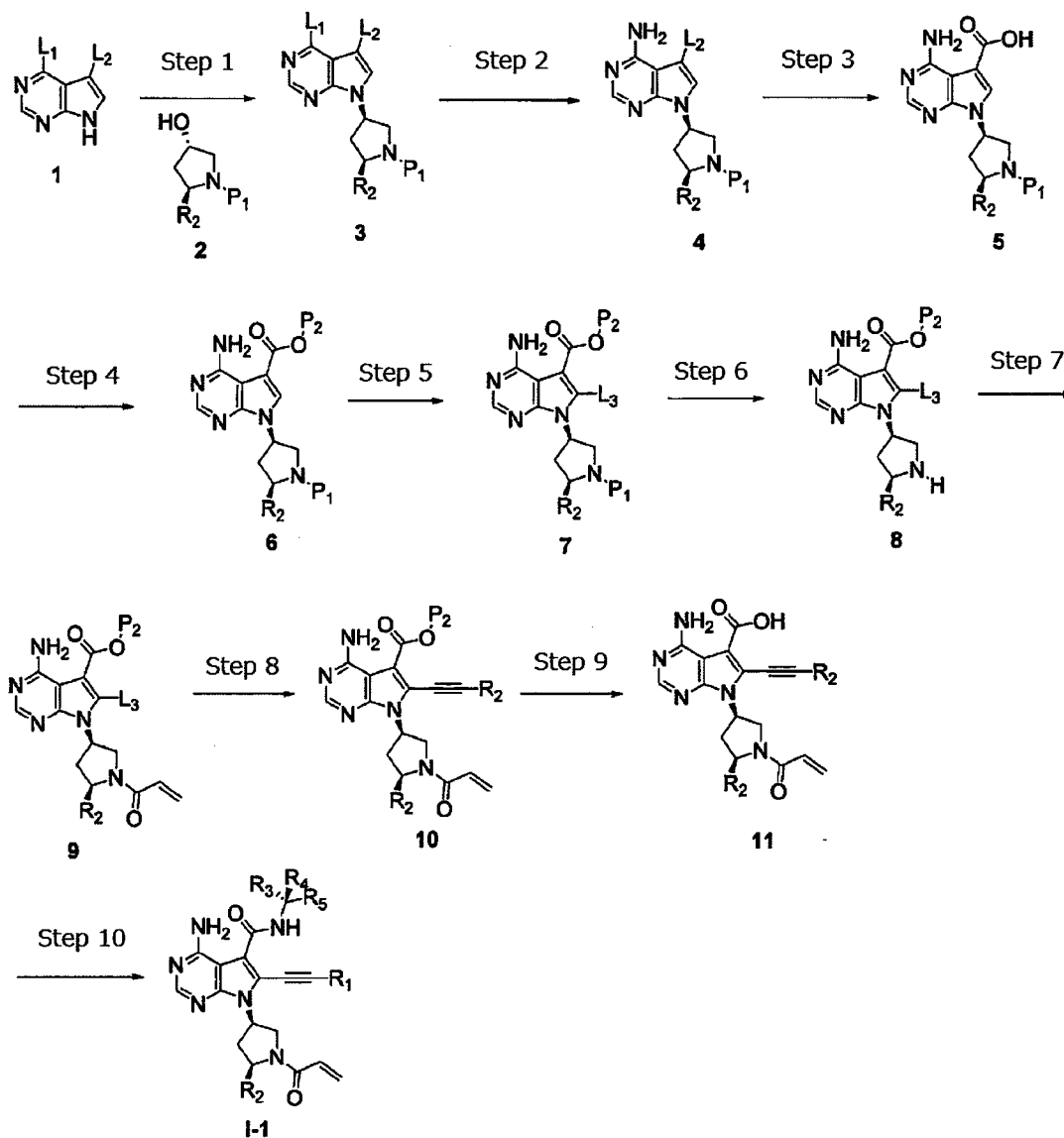
[0116]

< Method for producing compound represented by formula (I) >

The compound according to the present invention can be produced by, for example, the following production method or the methods described in the Examples. However, the method for producing the compound according to the present invention is not limited to these examples.

The compounds (I) and (II) of the present invention can be produced by applying, for example, the following production method.

< Production Method >



In the above process, L₁, L₂, and L₃, which are the same or different, each represent a leaving group; P₁ and P₂, which are the same or different, each represent a protective group; and other symbols are as defined above.

[0117]

< Step 1 >

This step is a method of obtaining a compound represented by the formula 3 by performing a Mitsunobu reaction between a compound represented by the formula 1 and a compound represented by the formula 2 that is a commercially available compound or can be produced by a known method. The Mitsunobu reaction is generally carried out in the presence of a Mitsunobu reagent and a phosphine reagent.

The compound represented by the formula 2 (in the formula 2, P₁ represents a

protective group for an amino group) can be used in an amount of 1 to 10 equivalents, and preferably 1 to 3 equivalents, based on the amount of the compound represented by the formula 1 (1 mole).

The "protective group for an amino group" is not particularly limited, as long as it has a protective function. Examples of the protective group for an amino group may include: aralkyl groups, such as a benzyl group, a p-methoxybenzyl group, a 3,4-dimethoxybenzyl group, an o-nitrobenzyl group, a p-nitrobenzyl group, a benzhydryl group, a trityl group, and a cumyl group; lower alkanoyl groups, such as, for example, a formyl group, an acetyl group, a propionyl group, a butyryl group, a pivaloyl group, a trifluoroacetyl group, and a trichloroacetyl group; for example, benzoyl groups; arylalkanoyl groups, such as, for example, a phenylacetyl group and a phenoxyacetyl group; lower alkoxy carbonyl groups, such as, for example, a methoxycarbonyl group, an ethoxycarbonyl group, a propyloxycarbonyl group, and a tert-butoxycarbonyl group; aralkyloxycarbonyl groups, such as, for example, a p-nitrobenzyloxycarbonyl group and a phenethyloxycarbonyl group; lower alkylsilyl groups, such as, for example, a trimethylsilyl group and a tert-butyldimethylsilyl group; for example, tetrahydropyranyl groups; for example, trimethylsilylethoxymethyl groups; lower alkylsulfonyl groups, etc., such as, for example, a methylsulfonyl group, an ethylsulfonyl group, and a tert-butylsulfonyl group; lower alkylsulfinyl groups, etc., such as for example, a tert-butylsulfinyl group; arylsulfonyl groups, etc., such as, for example, a benzenesulfonyl group and a toluenesulfonyl group; and imide groups, such as, for example, a phthalimide group. Among these, a trifluoroacetyl group, an acetyl group, a tert-butoxycarbonyl group, a benzyloxycarbonyl group, a trimethylsilylethoxymethyl group, or a cumyl group is particularly preferable.

[0118]

As a Mitsunobu reagent, diethyl azodicarboxylate, diisopropyl azodicarboxylate or the like is used. Such a Mitsunobu reagent is used in an amount of generally approximately 1 to 100 moles, and preferably approximately 1 to 10 moles, based on the compound represented by the formula 1 (1 mole).

As a phosphine reagent, triphenylphosphine, tributylphosphine, trifurylphosphine or the like is used. Such a phosphine reagent is used in an amount of generally approximately 1 to 100 moles, and preferably approximately 1 to 10 moles, based on the compound represented by the formula 1 (1 mole).

The solvent is not particularly limited, as long as it does not affect the reaction. Examples of the solvent may include hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., chloroform, 1,2-dichloroethane, etc.), nitriles (e.g.,

acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), alcohols (e.g., methanol, ethanol, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), water, and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 100° C.

The thus obtained compound represented by the formula 3 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0119]

< Step 2 >

This step is a method of obtaining a compound represented by the formula 4 by allowing the compound represented by the formula 3 to react with ammonia or a salt thereof.

The ammonia or a salt thereof can be used in an amount of 1 to 1000 equivalents, and preferably 1 to 100 equivalents, based on the amount of the compound represented by the formula 3 (1 mole).

The solvent is not particularly limited, as long as it does not affect the reaction. Examples of the solvent may include hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), alcohols (e.g., methanol, ethanol, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), water, and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 150° C.

The thus obtained compound represented by the formula 4 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0120]

< Step 3 >

This step is a method of obtaining a compound represented by the formula 5 by reacting the compound represented by the formula 4 under a carbon monoxide atmosphere, for example, in the presence of a transition metal catalyst, a base and alcohol.

In this step, the pressure of the carbon monoxide is generally from 1 to 20 atmospheres, and preferably 1 to 10 atmospheres.

Examples of the alcohol may include methanol, ethanol, propanol, isopropanol, diethylaminoethanol, isobutanol, 4-(2-hydroxyethyl)morpholine, 3-morpholinopropanol, and diethylaminopropanol.

The alcohol is used in an amount of generally approximately 1 to 100 moles, and preferably approximately 1 to 50 moles, based on the amount of the compound represented by the formula 4 (1 mole).

[0121]

Examples of the transition metal catalyst used herein may include palladium catalysts (e.g., palladium acetate, palladium chloride, tetrakis(triphenylphosphine) palladium, palladium carbon, etc.). A ligand (e.g., triphenylphosphine, tri-tert-butylphosphine, etc.) may be added, as necessary. The amount of the transition metal catalyst used is different depending on the type of the catalyst. The transition metal catalyst is used in an amount of generally approximately 0.0001 to 1 mole, and preferably approximately 0.01 to 0.5 moles, based on the amount of the compound 4 (1 mole). The ligand is used in an amount of generally approximately 0.0001 to 4 moles, and preferably approximately 0.01 to 2 moles, based on the amount of the compound represented by the formula 4 (1 mole).

[0122]

Examples of the base may include organic amines (e.g., trimethylamine, triethylamine, diisopropylethylamine, N-methylmorpholine, 1,8-diazabicyclo[5,4,0]undec-7-ene, pyridine, N,N-dimethylaniline, etc.), alkaline metal salts (e.g., sodium hydrogen carbonate, potassium hydrogen carbonate, sodium carbonate, potassium carbonate, cesium carbonate, sodium phosphate, potassium phosphate, sodium hydroxide, potassium hydroxide, etc.), metal hydrides (e.g., potassium hydride, sodium hydride, etc.), alkaline metal alkoxides (e.g., sodium methoxide, sodium ethoxide, sodium-tert-butoxide, potassium-tert-butoxide, etc.), and alkaline metal disilazides (e.g., lithium disilazide, sodium disilazide, potassium disilazide, etc.). Among others, alkaline metal salts such as potassium carbonate, cesium carbonate, sodium phosphate, and potassium phosphate, alkaline metal alkoxides such as sodium-tert-butoxide and potassium-tert-butoxide, organic amines such as triethylamine and diisopropylethylamine, and the like are preferable. The base is used in an amount of generally approximately 0.1 to 50 moles, and preferably approximately 1 to 20 moles, based on the amount of the compound represented by the formula 4 (1 mole).

[0123]

The solvent is not particularly limited, as long as it does not affect the reaction. Examples of the solvent may include hydrocarbons (e.g., benzene, toluene, xylene, etc.),

halogenated hydrocarbons (e.g., chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), alcohols (e.g., methanol, ethanol, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, N-methylpyrrolidone, etc.), water, and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 150° C.

[0124]

After completion of this reaction, an ester form corresponding to the used alcohol, or a mixture of the ester form and the compound represented by the formula 5 is subjected to a hydrolysis reaction, so that it can be converted to the compound represented by the formula 5.

As such a base, sodium hydrogen carbonate, sodium carbonate, potassium carbonate, cesium carbonate, sodium hydroxide, potassium hydroxide, lithium hydroxide, or the like is preferably used. The base is used in an amount of generally approximately 0.5 to 100 moles, and preferably approximately 1 to 10 moles, based on the amount of the compound represented by the formula 4 (1 mole).

The solvent is not particularly limited, as long as it does not affect the reaction. For example, water, methanol, ethanol, isopropanol, tetrahydrofuran, 1,4-dioxane, N,N-dimethylformamide and the like can be used alone or in combination. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 100° C.

The thus obtained compound represented by the formula 5 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0125]

< Step 4 >

This step is a method of obtaining a compound represented by the formula 6 (wherein P₂ represents a protective group for a carboxyl group) by introducing a protective group into the compound represented by the formula 5. Protection can be carried out according to a generally known method, for example, the method described in *Protective Groups in Organic Synthesis* third edition, T. W. Greene and P. G. M. Wuts, John Wiley & Sons (1999), or a method equivalent thereto.

The "protective group for a carboxyl group" is not particularly limited, as long as it has a protective function. Examples of the protective group for a carboxyl group may include: lower alkyl groups, such as, for example, a methyl group, an ethyl group, a

propyl group, an isopropyl group, and a tert-butyl group; halo lower alkyl groups, such as, for example, a 2,2,2-trichloroethyl group; lower alkenyl groups, such as, for example, an allyl group; for example, a trimethylsilylethoxymethyl group; and aralkyl groups, such as, for example, a benzyl group, a p-methoxybenzyl group, a p-nitrobenzyl group, a benzhydryl group, and a trityl group. In particular, a methyl group, an ethyl group, a tert-butyl group, an allyl group, a benzyl group, a p-methoxybenzyl group, or a trimethylsilylethoxymethyl group is preferable.

In the present reaction, a protective group such as, for example, a tert-butyl ester group, a methyl ester group, or an ethyl ester group, is preferably introduced.

The protective group agent used in the present reaction may be, for example, 2-tert-butyl-1,3-diisopropylisourea. Such a protective group agent is used in an amount of generally approximately 1 to 50 moles, and preferably approximately 1 to 10 moles, based on the amount of the compound represented by the formula 5 (1 mole).

The solvent is not particularly limited, as long as it does not affect the reaction. Examples of the solvent may include hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, tert-butyl methyl ether, etc.), alcohols (e.g., methanol, ethanol, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), water, and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 100°C.

The thus obtained compound represented by the formula 6 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0126]

< Step 5 >

This step is a method of obtaining a compound represented by the formula 7 (wherein L₃ represents a halogen atom) by halogenating the compound represented by the formula 6. Halogenation can be carried out by a method using fluorine, chlorine, bromine, iodine, etc., or by a method using N-chlorosuccinimide, N-bromosuccinimide, N-iodosuccinimide, etc. In the present reaction, the method using N-chlorosuccinimide, N-bromosuccinimide, N-iodosuccinimide, etc. is preferable.

N-chlorosuccinimide, N-bromosuccinimide, N-iodosuccinimide, etc. can be used in an amount of 1 to 10 equivalents, and preferably 1 to 3 equivalents, based on the amount of the compound represented by the formula 6 (1 mole).

The solvent is not particularly limited, as long as it does not affect the reaction. Examples of the solvent may include hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), alcohols (e.g., methanol, ethanol, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), water, and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 100°.

The thus obtained compound represented by the formula 7 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0127]

< Step 6 >

This step is a method of obtaining a compound represented by the formula 8 by removing the protective group for an amino group (P₁ in the formula 7) from the compound represented by the formula 7 (deprotection). Such deprotection can be carried out according to a generally known method, for example, the method described in Protective Groups in Organic Synthesis third edition, T. W. Greene and P. G. M. Wuts, John Wiley & Sons (1999), or a method equivalent thereto.

The protective group may be, for example, tert-butyloxycarbonyl. When such a tert-butyloxycarbonyl group is used, for example, as a protective group, deprotection is preferably carried out under acidic conditions. Examples of the acid used herein may include hydrochloric acid, acetic acid, trifluoroacetic acid, sulfuric acid, and tosylic acid.

The acid is preferably used in an amount of approximately 1 to 100 equivalents based on the amount of the compound represented by the formula 7 (1 mole).

The solvent used in the reaction is not particularly limited, as long as it does not affect the reaction. Examples of the solvent used herein may include alcohols (e.g., methanol, etc.), hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., methylene chloride, chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to 100°C, and preferably 0°C to 50°.

The thus obtained compound represented by the formula 8 can be isolated and

purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0128]

< Step 7 >

This step is a method of obtaining a compound represented by the formula 9 by performing an amidation reaction between an amino group of the compound represented by the formula 8 and acrylic acid halide or acrylic acid anhydride.

In the case of using acrylic acid halide or acrylic acid anhydride, such acrylic acid halide or acrylic acid anhydride is used in an amount of generally approximately 0.5 to 10 moles, and preferably approximately 1 to 5 moles, based on the amount of the compound represented by the formula 8 (1 mole). It is to be noted that the present acrylic acid halide or acrylic acid anhydride can be obtained as a commercially available product or can be produced according to a known method.

In addition, a base can be added, as necessary. Examples of the base may include organic amines (e.g., trimethylamine, triethylamine, isopropylethylamine, diisopropylethylamine, N-methylmorpholine, 1,8-diazabicyclo[5,4,0]undec-7-ene, pyridine, N,N-dimethylaniline, etc.), alkaline metal salts (e.g., sodium hydrogen carbonate, potassium hydrogen carbonate, sodium carbonate, potassium carbonate, cesium carbonate, sodium phosphate, potassium phosphate, sodium hydroxide, potassium hydroxide, etc.), metal hydrides (e.g., potassium hydride, sodium hydride, etc.), and alkaline metal alkoxides (e.g., sodium methoxide, sodium ethoxide, sodium-tert-butoxide, potassium-tert-butoxide, etc.). The base is used in an amount of generally approximately 1 to 100 moles, and preferably approximately 1 to 10 moles, based on the amount of the compound represented by the formula 8 (1 mole).

The solvent used in the reaction is not particularly limited, as long as it does not affect the reaction. Examples of the solvent used herein may include alcohols (e.g., methanol, etc.), hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., methylene chloride, chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 100°C.

The thus obtained compound represented by the formula 9 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0129]

< Step 8 >

This step is a method of obtaining a compound represented by the formula 10 by performing a Sonogashira reaction between the compound represented by the formula 9 and an acetylene derivative that is a commercially available product or can be produced by a known method.

The acetylene derivative can be used in an amount of 1 to 50 equivalents, and preferably 1 to 10 equivalents, based on the amount of the compound represented by the formula 9 (1 mole).

Examples of the transition metal catalyst used herein may include palladium catalysts (e.g., palladium acetate, palladium chloride, tetrakis(triphenylphosphine)palladium, dichlorobis(triphenylphosphine)palladium, etc.), and nickel catalysts (e.g., nickel chloride, etc.). As necessary, a ligand (e.g., triphenylphosphine, tri-tert-butylphosphine, etc.) may be added, and a copper catalyst (e.g., copper iodide, copper bromide, or copper chloride) or the like may be used as a co-catalyst. The amount of the transition metal catalyst used is different depending on the type of the catalyst. The transition metal catalyst is used in an amount of generally approximately 0.0001 to 1 mole, and preferably approximately 0.01 to 0.5 moles, based on the amount of the compound represented by the formula 9 (1 mole). The ligand is used in an amount of generally approximately 0.0001 to 4 moles, and preferably approximately 0.01 to 2 moles, based on the amount of the compound represented by the formula 9 (1 mole). The copper catalyst is used in an amount of generally approximately 0.0001 to 4 moles, and preferably approximately 0.010 to 2 moles, based on the amount of the compound represented by the formula 9 (1 mole).

[0130]

Examples of the base may include organic amines (e.g., trimethylamine, triethylamine, diisopropylethylamine, N-methylmorpholine, 1,8-diazabicyclo[5,4,0]undec-7-ene, pyridine, N,N-dimethylaniline, etc.), alkaline metal salts (e.g., sodium hydrogen carbonate, potassium hydrogen carbonate, sodium carbonate, potassium carbonate, cesium carbonate, sodium phosphate, potassium phosphate, sodium hydroxide, potassium hydroxide, etc.), metal hydrides (e.g., potassium hydride, sodium hydride, etc.), alkaline metal alkoxides (e.g., sodium methoxide, sodium ethoxide, sodium-tert-butoxide, potassium-tert-butoxide, etc.), and alkaline metal disilazide (e.g., lithium disilazide, sodium disilazide, potassium disilazide, etc.). Among these, preferred examples of the base may include: alkaline metal salts, such as potassium carbonate, cesium carbonate, sodium phosphate, and potassium phosphate; alkaline metal

alkoxides, such as sodium-tert-butoxide and potassium-tert-butoxide; and organic amines, such as triethylamine and diisopropylethylamine. The base is used in an amount of generally approximately 0.1 to 10 moles, and preferably approximately 1 to 5 moles, based on the amount of the compound represented by the formula 9 (1 mole).

The solvent is not particularly limited, as long as it does not affect the reaction. Examples of the solvent may include hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), alcohols (e.g., methanol, ethanol, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), water, and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 150° C.

The thus obtained compound represented by the formula 10 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0131]

< Step 9 >

This step is a method of obtaining a compound represented by the formula 11 by deprotecting the protective group for a carboxyl group (P₂ in the formula 10) of the compound represented by the formula 10. Deprotection can be carried out according to a generally known method, for example, the method described in Protective Groups in Organic Synthesis third edition, T. W. Greene and P. G. M. Wuts, John Wiley & Sons (1981), or a method equivalent thereto.

The protective group may be, for example, tert-butyl ester. When such a tert-butyl ester group is used as a protective group, for example, deprotection is preferably carried out under acidic conditions. Examples of the acid used herein may include hydrochloric acid, acetic acid, trifluoroacetic acid, sulfuric acid, and tosylic acid.

The acid is preferably used in an amount of approximately 1 to 100 equivalents based on the amount of the compound represented by the formula 10 (1 mole).

The solvent used in the reaction is not particularly limited, as long as it does not affect the reaction. Examples of the solvent used herein may include alcohols (e.g., methanol, etc.), hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., methylene chloride, chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, ,

etc.), and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to 100°C, and preferably 0°C to 50°.

The thus obtained compound represented by the formula 11 can be isolated and purified by known separation and purification means, or can be subjected to the subsequent step without isolation and purification.

[0132]

< Step 10 >

This step is a method of obtaining a compound represented by the formula (I) by performing an amidation reaction between a carboxyl group of the compound represented by the formula 11 and an amine that is a commercially available product or can be produced by a known method.

Amidation can be carried out according to a conventionally known method. Examples of the amidation method may include a method of performing the reaction in the presence of a condensing agent, and a method comprising activating a carboxylic acid portion according to a conventionally known method to obtain a reactive derivative, and then performing amidation between the derivative and an amine (for both methods, see "*Peptide Gosei no Kiso to Jikken* (Principle of Peptide Synthesis and Experiments)" (Nobuo IZUMIYA et al., Maruzen Co., Ltd., 1983)).

Examples of the condensing agent may include N,N'-dicyclohexylcarbodiimide (DCC), N,N'-diisopropylcarbodiimide (DIC), 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (WSC), diphenylphosphoryl azide (DPPA), benzotriazol-1-yl-oxytrisdimethylaminophosphonium hexafluorophosphate (BOP), benzotriazol-1-yl-oxytripyrrolidinophosphonium hexafluorophosphate (PyBOP), 7-azabenzotriazol-1-yloxytrispyrrolidinophosphonium phosphate (PyAOP), bromotrispyrrolidinophosphonium hexafluorophosphate (BroP), chlorotris(pyrrolidin-1-yl)phosphonium hexafluorophosphate (PyCroP), 3-(diethoxyphosphoryloxy)-1,2,3-benzotriazin-4(3H)-one (DEPBT), O-(azabenzotriazol-1-yl)-N,N,N',N'-tetramethyluronium hexafluorophosphate (HATU), and 4-(5,6-dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholine hydrochloride (DMTMM). Examples of the additive used at that time may include 1-hydroxybenzotriazole (HOBt), 1-hydroxy-7-azabenzotriazole (HOAt), and N-hydroxysuccinimide (HOSu). Such agents are used in an amount of generally approximately 1 to 100 moles, and preferably approximately 1 to 10 moles, based on the amount of the compound represented by the formula 11 (1 mole).

[0133]

In addition, as necessary, a base can be added. Examples of such a base may

include organic amines (e.g., trimethylamine, triethylamine, diisopropylethylamine, N-methylmorpholine, 1,8-diazabicyclo[5,4,0]undec-7-ene, pyridine, N,N-dimethylaniline, etc.), alkaline metal salts (e.g., sodium hydrogen carbonate, potassium hydrogen carbonate, sodium carbonate, potassium carbonate, cesium carbonate, sodium phosphate, potassium phosphate, sodium hydroxide, potassium hydroxide, etc.), metal hydrides (e.g., potassium hydride, sodium hydride, etc.), and alkaline metal alkoxides (e.g., sodium methoxide, sodium ethoxide, sodium-tert-butoxide, potassium-tert-butoxide, etc.). The base is used in an amount of generally approximately 1 to 100 moles, and preferably approximately 1 to 10 moles, based on the amount of the compound represented by the formula 11 (1 mole).

The solvent used in the reaction is not particularly limited, as long as it does not affect the reaction. Examples of the solvent used herein may include alcohols (e.g., methanol, etc.), hydrocarbons (e.g., benzene, toluene, xylene, etc.), halogenated hydrocarbons (e.g., methylene chloride, chloroform, 1,2-dichloroethane, etc.), nitriles (e.g., acetonitrile, etc.), ethers (e.g., dimethoxyethane, tetrahydrofuran, etc.), aprotic polar solvents (e.g., N,N-dimethylformamide, dimethyl sulfoxide, hexamethylphosphoramide, etc.), and mixtures thereof. The reaction time is 0.1 to 100 hours, and preferably 0.5 to 24 hours. Thereafter, the reaction temperature is 0°C to the temperature at which the solvent is boiled, and preferably 0°C to 100°C.

The thus obtained compounds (I) and (II) can be isolated and purified according to known separation and purification means, such as, for example, concentration, vacuum concentration, crystallization, solvent extraction, re-precipitation, or chromatography.

In the above-described production method, the steps ranging from the "introduction of a protective group into a carboxyl group of the compound represented by the formula 5" (Step 4) to the "amidation reaction between a carboxyl group of the compound represented by the formula 11 and an amine that is a commercially available product or can be produced by a known method" (Step 10) are successively carried out in this order. However, the order of performing these steps can be changed. Moreover, the "introduction of a protective group into a carboxyl group of the compound represented by the formula 5" (Step 4) and the "removal of the protective group for a carboxy group from the compound represented by the formula 10" (Step 9) can be omitted.

[0134]

Specifically, individual steps are carried out in the order of the "amidation reaction between a carboxyl group of the compound represented by the formula 11 and an amine that is a commercially available product or can be produced by a known method" (Step 10), the "halogenation of the compound represented by the formula 6" (Step 5), the

"removal of the protective group for an amino group from the compound represented by the formula 7" (Step 6), the "amidation reaction between an amino group of the compound represented by the formula 8 and acrylic acid halide or acrylic acid anhydride" (Step 7), and the "Sonogashira reaction between the compound represented by the formula 9 and an acetylene derivative that is a commercially available product or can be produced by a known method, when L3 of the compound represented by the formula 9 has a leaving group such as halogen" (Step 8), so that the concerned compound can be induced to the compounds represented by the formulae (I) and (II). The conditions applied in individual steps are the same as those as described above.

[0135]

When the pyrimidine compound of the present invention has an isomer, such as an optical isomer, a stereoisomer, a rotational isomer, or a tautomer, all of these isomers or mixtures thereof are included in the pyrimidine compound of the present invention, unless otherwise stated. For example, when the pyrimidine compound of the present invention has an optical isomer, both a racemate, and an optical isomer obtained as a result of racemic resolution are included in the pyrimidine compound of the present invention, unless otherwise stated.

[0136]

The salt of the pyrimidine compound of the present invention means a pharmaceutically acceptable salt, and it may be, for example, a base-added salt or an acid-added salt.

[0137]

The pyrimidine compound of the present invention or a salt thereof also includes a prodrug. The "prodrug" means a compound that is converted to the pyrimidine compound of the present invention or a salt thereof as a result of the reaction with an enzyme, stomach acid, etc. under physiological conditions in a living body; namely, a compound that enzymatically causes oxidation, reduction, hydrolysis, etc., so that it is converted to the pyrimidine compound of the present invention or a salt thereof, or a compound that causes hydrolysis, etc. with stomach acid or the like, so that it is converted to the pyrimidine compound of the present invention or a salt thereof. Otherwise, it may also be a compound that is converted to the pyrimidine compound of the present invention or a salt thereof under physiological conditions as described in "*Iyakuhiin no Kaihatsu* (Development of Pharmaceutical Products)," Hirokawa Shoten, 1990, Vol. 7, *Bunshi Sekkei* (Molecular Designing), pp. 163 to 198.

[0138]

The pyrimidine compound of the present invention or a salt thereof may be an

amorphous material or a crystal. Although the crystal form thereof may be a single crystal or a polymorphic mixture, they are included in the pyrimidine compound of the present invention or a salt thereof. The crystal can be produced by crystallizing the pyrimidine compound of the present invention or a salt thereof, applying a known crystallization method. The pyrimidine compound of the present invention or a salt thereof may be either a solvate (e.g., a hydrate, etc.), or a non-solvate, and both of them are included in the compound of the present invention or a salt thereof. Compounds labeled with radioisotopes (e.g., ^3H , ^{14}C , ^{35}S , ^{125}I , etc.) and the like are also included in the pyrimidine compound of the present invention or a salt thereof.

[0139]

Examples of the other antitumor agent include, but are not particularly limited to, antimetabolites, molecular targeting drugs, platinum drugs, and vegetable alkaloid drugs. These other antitumor agents can be used singly or in combination of two or more thereof.

[0140]

Examples of the antimetabolite include, but are not particularly limited to, 5-fluorouracil (5-FU), 5-fluoro-2'-deoxyuridine (FdUrd), tegafur, tegafur-uracil combination drugs (e.g., UFT(R)), tegafur-gimeracil-oteracil combination drugs (e.g., TS-1(R)), trifluridine (FTD), trifluridine-tipiracil hydrochloride combination drugs (e.g., Lonsurf(R)), gemcitabine, capecitabine, and cytarabine. Preferable is 5-Fluorouracil (5-FU), trifluridine (FTD), gemcitabine, or capecitabine. These antimetabolites can be used singly or in combination of two or more thereof.

[0141]

Examples of the molecular targeting drug include ErbB family (EGFR, Her2, Her3, or Her4) inhibitors, PI3K/AKT/mTOR inhibitors, CDK4/6 inhibitors, and estrogen receptor antagonists. These molecular targeting drugs can be used singly or in combination of two or more thereof.

[0142]

The ErbB family (EGFR, Her2, Her3, Her4) inhibitor is preferably a Her2 inhibitor, more preferably an anti-Her2 antibody such as trastuzumab, pertuzumab, trastuzumab emtansine, trastuzumab deruxtecan, or trastuzumab duocarmazine, and still more preferably trastuzumab, pertuzumab, or trastuzumab emtansine. These ErbB family inhibitors can be used singly or in combination of two or more thereof. In one embodiment, the ErbB family inhibitor is trastuzumab and pertuzumab.

[0143]

The PI3K/AKT/mTOR inhibitor is a compound that inhibits the signaling

pathway of PI3K/AKT/mTOR. Examples thereof include AZD5363, AZD8055, everolimus (RAD001), dactolisib (BEZ235), buparlisib (BKM120), taselisib (GDC-0032), MK2206, and trans-3-amino-1-methyl-3-[4-(3-phenyl-5H-imidazo[1,2-c]pyrido[3,4-e][1,3]oxazin-2-yl)phenyl]-cyclobutanol. Preferable is AZD8055, everolimus, dactolisib, buparlisib, taselisib, or MK2206. These PI3K/AKT/mTOR inhibitors can be used singly or in combination of two or more thereof.

[0144]

Examples of the CDK4/6 inhibitor include palbociclib and abemaciclib. Preferable is palbociclib. These CDK4/6 inhibitors can be used singly or in combination of two or more thereof.

[0145]

Examples of the estrogen receptor antagonist include fulvestrant, tamoxifen, and mepitiostane. Preferable is fulvestrant. These estrogen receptor antagonists can be used singly or in combination of two or more thereof.

[0146]

Examples of the platinum drug include oxaliplatin, carboplatin, cisplatin, and nedaplatin. Preferable is cisplatin. These platinum drugs can be used singly or in combination of two or more thereof.

[0147]

Examples of the vegetable alkaloid drug include microtubule inhibitors such as paclitaxel, docetaxel, vinblastine, vincristine, vindesine, vinorelbine, and eribulin, and topoisomerase inhibitors such as irinotecan, nogitecan, and etoposide. More preferable is a taxane microtubule inhibitor such as paclitaxel or docetaxel, or a topoisomerase I inhibitor such as irinotecan or nogitecan, and still more preferable is paclitaxel or irinotecan. These vegetable alkaloid drugs can be used singly or in combination of two or more thereof.

[0148]

The other antitumor agent is preferably at least one antimetabolite, molecular targeting drug, platinum drug, or vegetable alkaloid drug, more preferably at least one antimetabolite, ErbB family (EGFR, Her2, Her3, or Her4) inhibitor, PI3K/AKT/mTOR inhibitor, CDK4/6 inhibitor, estrogen receptor antagonist, platinum drug, or vegetable alkaloid drug, still more preferably at least one antimetabolite, Her2 inhibitor, PI3K/AKT/mTOR inhibitor, CDK4/6 inhibitor, estrogen receptor antagonist, platinum drug, or vegetable alkaloid drug, even more preferably at least one antimetabolite, Her2 inhibitor, PI3K/AKT/mTOR inhibitor, CDK4/6 inhibitor, estrogen receptor antagonist, platinum drug, microtubule inhibitor, or topoisomerase I inhibitor, yet more preferably at

least one antimetabolite, Her2 inhibitor, PI3K/AKT/mTOR inhibitor, CDK4/6 inhibitor, estrogen receptor antagonist, platinum drug, taxane microtubule inhibitor, or topoisomerase I inhibitor, further preferably at least one agent selected from 5-fluorouracil (5-FU), 5-fluoro-2'-deoxyuridine (FdUrd), tegafur, tegafur-uracil combination drugs (e.g., UFT(R)), tegafur-gimeracil-oteracil combination drugs (e.g., TS-1(R)), trifluridine, trifluridine-tipiracil hydrochloride combination drugs (e.g., Lonsurf(R)), gemcitabine, capecitabine, cytarabine, trastuzumab, pertuzumab, trastuzumab emtansine, trastuzumab deruxtecan, trastuzumab duocarmazine, AZD5363, AZD8055, everolimus, dactolisib, buparlisib, taselisib, MK2206, trans-3-amino-1-methyl-3-[4-(3-phenyl-5H-imidazo[1,2-c]pyrido[3,4-e][1,3]oxazin-2-yl)phenyl]-cyclobutanol, palbociclib, abemaciclib, fulvestrant, tamoxifen, mepitiostane, oxaliplatin, carboplatin, cisplatin, nedaplatin, paclitaxel, and docetaxel, still further preferably at least one agent selected from 5-fluorouracil (5-FU), trifluridine, gemcitabine, capecitabine, trastuzumab, pertuzumab, trastuzumab emtansine, AZD8055, everolimus, dactolisib, buparlisib, taselisib, palbociclib, fulvestrant, cisplatin, and paclitaxel, and particularly preferably at least one agent selected from capecitabine, trastuzumab, pertuzumab and trastuzumab emtansine.

The other antitumor agent also includes DDS preparations thereof. For example, "paclitaxel" includes albumin-bound paclitaxel (e.g., Abraxane(R)) and paclitaxel micelle (e.g., NK105), etc. "Cisplatin" includes cisplatin micelle (e.g., NC-6004), etc.

[0149]

In one embodiment of the present invention, examples of antitumor agents include chemotherapeutic agents (e.g., cytotoxic agents), immunotherapeutic agents, hormonal and anti-hormonal agents, targeted therapy agents, and anti-angiogenesis agents. Many antitumor agents can be classified within one or more of these groups. While certain antitumor agents have been categorized within a specific group(s) or subgroup(s) herein, many of these agents can also be listed within one or more other group(s) or subgroup(s), as would be presently understood in the art. The antitumor agent is not particularly limited, and examples thereof include, but are not limited to, a chemotherapeutic agent, a mitotic inhibitor, a plant alkaloid, an alkylating agent, an antimetabolite, a platinum analog, an enzyme, a topoisomerase inhibitor, a retinoid, an aziridine, an antibiotic, a hormonal agent, an anti-hormonal agent, an anti-estrogen, an anti-androgen, an anti-adrenal, an androgen, a targeted therapy agent, an immunotherapeutic agent, a biological response modifier, a cytokine inhibitor, a tumor vaccine, a monoclonal antibody, an immune checkpoint inhibitor, an anti-PD-1 agent, an

anti-PD-L1 agent, a colony-stimulating factor, an immunomodulator, an immunomodulatory imide (IMiD), an anti-CTLA4 agent, an anti-LAG1 agent, an anti-OX40 agent, a GITR agonist, a CAR-T cell, a BiTE, a signal transduction inhibitor, a growth factor inhibitor, a tyrosine kinase inhibitor, an EGFR inhibitor, a HER2 inhibitor, a histone deacetylase (HDAC) inhibitor, a proteasome inhibitor, a cell-cycle inhibitor, an anti-angiogenesis agent, a matrix-metalloproteinase (MMP) inhibitor, a hepatocyte growth factor inhibitor, a TOR inhibitor, a KDR inhibitor, a VEGF inhibitor, a HIF-1 α inhibitor, a HIF-2 α inhibitor, a fibroblast growth factor (FGF) inhibitor, a RAF inhibitor, a MEK inhibitor, an ERK inhibitor, a PI3K inhibitor, an AKT inhibitor, an MCL-1 inhibitor, a BCL-2 inhibitor, an SHP2 inhibitor, a BRAF-inhibitor, a RAS inhibitor, a gene expression modulator, an autophagy inhibitor, an apoptosis inducer, an antiproliferative agent, and a glycolysis inhibitor.

[0150]

Non-limiting examples of chemotherapeutic agents include mitotic inhibitors and plant alkaloids, alkylating agents, anti-metabolites, platinum analogs, enzymes, topoisomerase inhibitors, retinoids, aziridines, and antibiotics.

[0151]

Non-limiting examples of mitotic inhibitors and plant alkaloids include taxanes such as cabazitaxel, docetaxel, larotaxel, ortataxel, paclitaxel, and tesetaxel; demecolcine; epothilone; eribulin; etoposide (VP16); etoposide phosphate; navelbine; noscapine; teniposide; thaliblastine; vinblastine; vincristine; vindesine; vinflunine; and vinorelbine.

[0152]

Non-limiting examples of alkylating agents include nitrogen mustards such as chlorambucil, chlornaphazine, cholophosphamide, cytophosphane, estramustine, ifosfamide, mannomustine, mechlorethamine, mechlorethamine oxide hydrochloride, melphalan, novembichin, phenesterine, prednimustine, tris(2-chloroethyl)amine, trofosfamide, and uracil mustard; alkyl sulfonates such as busulfan, improsulfan, and piposulfan; nitrosoureas such as carmustine, chlorozotocin, fotemustine, lomustine, nimustine, ranimustine, streptozotocin, and TA-07; ethylenimines and methylamelamines such as altretamine, thiotepa, triethylenemelamine, triethylenethiophosphaoramide, triethylenephosphoramidate, and trimethylolomelamine; ambamustine; bendamustine; dacarbazine; cyclophosphamide; etoglucid; irofulven; mafosfamide; mitobronitol; mitolactol; pipobroman; procarbazine; temozolomide; treosulfan; and triaziquone.

[0153]

Non-limiting examples of anti-metabolites include folic acid analogues such as aminopterin, denopterin, edatrexate, methotrexate, pteropterin, raltitrexed, and

trimetrexate; purine analogs such as 6-mercaptopurine, 6-thioguanine, fludarabine, forodesine, thiamiprine, and thioguanine; pyrimidine analogs such as 5-fluorouracil (5-FU), tegafur/gimeracil/oteracil potassium, tegafur/uracil, trifluridine, trifluridine/tipiracil hydrochloride, 6-azauridine, ancitabine, azacytidine, capecitabine, carmofur, cytarabine, decitabine, dideoxyuridine, doxifiuridine, doxifluridine, enocitabine, floxuridine, galocitabine, gemcitabine, and sapacitabine; 3-aminopyridine-2-carboxaldehyde thiosemicarbazone; broxuridine; cladribine; cyclophosphamide; cytarabine; emitefur; hydroxyurea; mercaptopurine; nelarabine; pemetrexed; pentostatin; tegafur; and troxacitabine.

[0154]

Non-limiting examples of platinum analogs include carboplatin, cisplatin, dicycloplatin, heptaplatin, lobaplatin, nedaplatin, oxaliplatin, satraplatin, and triplatin tetranitrate.

[0155]

Non-limiting examples of enzymes include asparaginase and pegaspargase.

[0156]

Non-limiting examples of topoisomerase inhibitors include acridine carboxamide, amonafide, amsacrine, belotecan, elliptinium acetate, exatecan, indolocarbazole, irinotecan, lurtotecan, mitoxantrone, razoxane, rubitecan, SN-38, sobuzoxane, and topotecan.

[0157]

Non-limiting examples of retinoids include alitretinoin, bexarotene, fenretinide, isotretinoin, liarozole, RII retinamide, and tretinoin.

[0158]

Non-limiting examples of aziridines include benzodopa, carboquone, meturedopa, and uredopa.

[0159]

Non-limiting examples of antibiotics include intercalating antibiotics; anthracenediones; anthracycline antibiotics such as aclarubicin, amrubicin, daunomycin, daunorubicin, doxorubicin, epirubicin, idarubicin, menogaril, nogalamycin, pirarubicin, and valrubicin; 6-diazo-5-oxo-L-norleucine; aclacinomycins; actinomycin; authramycin; azaserine; bleomycins; cactinomycin; calicheamicin; carabycin; carminomycin; carzinophilin; chromomycins; dactinomycin; detorubicin; esorubicin; esperamicins; geldanamycin; marcellomycin; mitomycins; mitomycin C; mycophenolic acid; olivomycins; novantrone; peplomycin; porfiromycin; potfiromycin; puromycin; quelamycin; rebeccamycin; rodorubicin; streptonigrin; streptozocin; *tanespimycin*;

tubercidin; ubenimex; zinostatin; zinostatin stimalamer; and zorubicin.

[0160]

Non-limiting examples of hormonal and anti-hormonal agents include anti-androgens such as abiraterone, apalutamide, bicalutamide, darolutamide, enzalutamide, flutamide, goserelin, leuprolide, and nilutamide; anti-estrogens such as 4- hydroxy tamoxifen, aromatase inhibiting 4(5)-imidazoles, EM-800, fosfestrol, fulvestrant, keoxifene, LY 117018, onapristone, raloxifene, tamoxifen, toremifene, and trioxifene; anti-adrenals such as aminoglutethimide, dexaminoglutethimide, mitotane, and trilostane; androgens such as calusterone, dromostanolone propionate, epitiostanol, mepitiothane, and testolactone; abarelix; anastrozole; cetrorelix; deslorelin; exemestane; fadrozole; finasteride; formestane; histrelin (RL 0903); human chorionic gonadotropin; lanreotide; LDI 200 (Milkhaus); letrozole; leuprorelin; mifepristone; nafarelin; nafoxidine; osaterone; prednisone; thyrotropin alfa; and triptorelin.

[0161]

Non-limiting examples of immunotherapeutic agents (i.e., immunotherapy) include biological response modifiers, cytokine inhibitors, tumor vaccines, monoclonal antibodies, immune checkpoint inhibitors, colony-stimulating factors, and immunomodulators.

[0162]

Non-limiting examples of biological response modifiers, including cytokine inhibitors (cytokines) such as interferons and interleukins, include interferon alfa/interferon alpha such as interferon alfa-2, interferon alfa-2a, interferon alfa-2b, interferon alfa-n1, interferon alfa-n3, interferon alfacon-1, peginterferon alfa-2a, peginterferon alfa-2b, and leukocyte alpha interferon; interferon beta such as interferon beta-1a, and interferon beta-1b; interferon gamma such as natural interferon gamma-1a, and interferon gamma-1b; aldesleukin; interleukin-1 beta; interleukin-2; oprelvekin; sonermin; tasonermin; and virulizin.

[0163]

Non-limiting examples of tumor vaccines include APC 8015, AVICINE, bladder cancer vaccine, cancer vaccine (Biomira), gastrin 17 immunogen, Maruyama vaccine, melanoma lysate vaccine, melanoma oncolysate vaccine (New York Medical College), melanoma vaccine (New York University), melanoma vaccine (Sloan Kettering Institute), TICE® BCG (Bacillus Calmette-Guerin), and viral melanoma cell lysates vaccine (Royal Newcastle Hospital).

[0164]

Non-limiting examples of monoclonal antibodies include abagovomab,

adecatumumab, aflibercept, alemtuzumab, blinatumomab, brentuximab vedotin, CA 125 MAb (Biomira), cancer MAb (Japan Pharmaceutical Development), daclizumab, daratumumab, denosumab, edrecolomab, gemtuzumab zogamicin, HER-2 and Fc MAb (Medarex), ibritumomab tiuxetan, idiotypic 105AD7 MAb (CRC Technology), idiotypic CEA MAb (Trilex), ipilimumab, lintuzumab, LYM-1 -iodine 131 MAb (Techni clone), mitumomab, moxetumomab, ofatumumab, polymorphic epithelial mucin-yttrium 90 MAb (Antisoma), ranibizumab, rituximab, veltuzumab, and trastuzumab.

[0165]

Non-limiting examples of immune checkpoint inhibitors include anti-PD-1 agents or antibodies such as cemiplimab, nivolumab, and pembrolizumab; anti-PD-L1 agents or antibodies such as atezolizumab, avelumab, and durvalumab; anti-CTLA-4 agents or antibodies such as ipilimumab and tremelimumab; anti-LAG1 agents; and anti-OX40 agents.

[0166]

Non-limiting examples of colony-stimulating factors include darbepoetin alfa, epoetin alfa, epoetin beta, filgrastim, granulocyte macrophage colony stimulating factor, lenograstim, leridistim, mirimostim, molgramostim, nartograstim, pegfilgrastim, and sargramostim.

[0167]

Non-limiting examples of additional immunotherapeutic agents include BiTEs, CAR-T cells, G1TR agonists, imiquimod, immunomodulatory imides (IMiDs), mismatched double stranded RNA (Ampligen), resiquimod, SRL 172, and thymalfasin. Targeted therapy agents include, for example, monoclonal antibodies and small molecule drugs.

[0168]

Non-limiting examples of targeted therapy agents include signal transduction inhibitors, growth factor inhibitors, tyrosine kinase inhibitors, EGFR inhibitors, HER2 inhibitors, histone deacetylase (HDAC) inhibitors, proteasome inhibitors, cell-cycle inhibitors, angiogenesis inhibitors, matrix-metalloproteinase (MMP) inhibitors, hepatocyte growth factor inhibitors, TOR inhibitors, KDR inhibitors, VEGF inhibitors, fibroblast growth factors (FGF) inhibitors, RAF inhibitors, MEK inhibitors, ERK inhibitors, PI3K inhibitors, AKT inhibitors, MCL-1 inhibitors, BCL-2 inhibitors, SHP2 inhibitors, BRAF-inhibitors, RAS inhibitors, gene expression modulators, autophagy inhibitors, apoptosis inducers, antiproliferative agents, and glycolysis inhibitors.

[0169]

Non-limiting examples of signal transduction inhibitors include tyrosine kinase

inhibitors, multiple-kinase inhibitors, anlotinib, avapritinib, axitinib, dasatinib, dovitinib, imatinib, lenvatinib, lonidamine, nilotinib, nintedanib, pazopanib, pegvisomant, ponatinib, vandetanib, and EGFR and/or HER2 inhibitory agents (i.e., other than formula (I) or its salt).

[0170]

Non-limiting examples of EGFR inhibitors include small molecule antagonists of EGFR such as afatinib, brigatinib, erlotinib, gefitinib, lapatinib, neratinib, dacomitinib, vandetanib, and osimertinib antibody-based EGFR inhibitors, including any anti-EGFR antibody or antibody fragment that can partially or completely block EGFR activation by its natural ligand; and specific antisense nucleotide or siRNA;. Antibody-based EGFR inhibitory agents may include, for example, those described in Modjtahedi, H., et al., 1993, *Br. J. Cancer* 67:247-253; Teramoto, T., et al., 1996, *Cancer* 77:639-645; Goldstein et al., 1995, *Clin. Cancer Res.* 1 : 1311-1318; Huang, S. M., et al., 1999, *Cancer Res.* 15:59(8): 1935-40; and Yang, X., et al., 1999, *Cancer Res.* 59: 1236-1243; monoclonal antibody Mab E7.6.3 (Yang, 1999 *supra*); Mab C225 (ATCC Accession No. HB-8508), or an antibody or antibody fragment having the binding specificity thereof; cetuximab; matuzumab; necitumumab; nimotuzumab; panitumumab; and zalutumumab.

[0171]

Non-limiting examples of HER2 inhibitors include HER2 tyrosine kinase inhibitors such as afatinib, lapatinib, neratinib, and tucatinib; and anti-HER2 antibodies or drug conjugates thereof such as trastuzumab, trastuzumab emtansine (T-DM1), pertuzumab, margetuximab, trastuzumab deruxtecan (DS-8201a), and trastuzumab duocarmazine.

[0172]

Non-limiting examples of histone deacetylase (HDAC) inhibitors include belinostat, panobinostat, romidepsin, and vorinostat.

[0173]

Non-limiting examples of proteasome inhibitors include bortezomib, carfilzomib, ixazomib, marizomib (salinosporamide a), and oprozomib.

[0174]

Non-limiting examples of cell-cycle inhibitors, including CDK inhibitors, include abemaciclib, alvocidib, palbociclib, and ribociclib.

[0175]

Non-limiting examples of anti-angiogenic agents (or angiogenesis inhibitors) include, but not limited to, matrix-metalloproteinase (MMP) inhibitors; VEGF inhibitors; EGFR inhibitors; TOR inhibitors such as everolimus and temsirolimus; PDGFR kinase

inhibitory agents such as crenolanib; HIF-1 α inhibitors such as PX 478; HIF-2 α inhibitors such as belzutifan and the HIF-2 α inhibitors described in WO 2015/035223; fibroblast growth factor (FGF) or FGFR inhibitory agents such as B-FGF and RG 13577; hepatocyte growth factor inhibitors; KDR inhibitors; anti-Ang1 and anti-Ang2 inhibitory agents; Tie2 kinase inhibitory agents; Tek antagonists (US 2003/0162712; US 6,413,932); anti-TWEAK agents (US 6,727,225); ADAM disintegrin domain to antagonize the binding of integrin to its ligands (US 2002/0042368); anti-eph receptor and/or anti-eph antibodies or antigen binding regions (US 5,981,245; 5,728,813; 5,969,110; 6,596,852; 6,232,447; and 6,057,124); and anti-PDGF-BB antagonists as well as antibodies or antigen binding regions specifically binding to PDGF-BB ligands.

[0176]

Non-limiting examples of matrix-metalloproteinase (MMP) inhibitors include MMP-2 (matrix-metalloproteinase 2) inhibitors, MMP-9 (matrix-metalloproteinase 9) inhibitors, prinomastat, RO 32-3555, and RS 13-0830. Examples of useful matrix metalloproteinase inhibitors are described, for example, in WO 96/33172, WO 96/27583, EP 1004578, WO 98/07697, WO 98/03516, WO 98/34918, WO 98/34915, WO 98/33768, WO 98/30566, EP 0606046, EP 0931788, WO 90/05719, WO 99/52910, WO 99/52889, WO 99/29667, WO 1999/007675, EP 1786785, EP 1181017, US 2009/0012085, US 5,863,949, US 5,861,510, and EP 0780386. Preferred MMP-2 and MMP-9 inhibitors are those that have little or no activity inhibiting MMP-1. More preferred, are those that selectively inhibit MMP-2 and/or MMP-9 relative to the other matrix-metalloproteinases (i.e., MMP-1, MMP-3, MMP-4, MMP-5, MMP-6, MMP-7, MMP-8, MMP-10, MMP-11, MMP-12, and MMP-13).

[0177]

Non-limiting examples of VEGF and VEGFR inhibitory agents include bevacizumab, cediranib, CEP 7055, CP 547632, KRN 633, orantinib, pazopanib, pegaptanib, pegaptanib octasodium, semaxanib, sorafenib, sunitinib, VEGF antagonist (Boreau, Denmark), and VEGF-TRAP™.

[0178]

Other anti-angiogenic agents may include, but are not limited to, 2-methoxyestradiol, AE 941, alemtuzumab, alpha-D148 Mab (Amgen, US), alphastatin, anecortave acetate, angiocidin, angiogenesis inhibitors (SUGEN, US), angiostatin, anti-Vn Mab (Crucell, Netherlands), atiprimod, axitinib, AZD 9935, BAY RES 2690 (Bayer, Germany), BC 1 (Genoa Institute of Cancer Research, Italy), belorantinib, benefin (Lane Labs, US), cabozantinib, CDP 791 (Celltech Group, UK), chondroitinase AC, cilengitide, combretastatin A4 prodrug, CP 564959 (OSI, US), CV247, CYC 381 (Harvard University,

US), E 7820, EHT 0101, endostatin, enzastaurin hydrochloride, ER-68203-00 (IVAX, US), fibrinogen-E fragment, Flk-1 (ImClone Systems, US), forms of FLT 1 (VEGFR 1), FR-111142, GCS-100, GW 2286 (GlaxoSmithKline, UK), IL-8, ilomastat, IM-862, irsogladine, KM-2550 (Kyowa Hakko, Japan), lenalidomide, lenvatinib, MAb alpha5beta3 integrin, VEGF (Xenova, UK), marimastat, maspin (Sosei, Japan), metastatin, motuporamine C, M-PGA, ombrabulin, OXI4503, PI 88, platelet factor 4, PPI 2458, ramucirumab, rBPI 21 and BPI-derived antiangiogenic (XOMA, US), regorafenib, SC-236, SD-7784 (Pfizer, US), SDX 103 (University of California at San Diego, US), SG 292 (Telios, US), SU-0879 (Pfizer, US), TAN-1120, TBC-1635, tesevatinib, tetrathiomolybdate, thalidomide, thrombospondin 1 inhibitor, Tie-2 ligands (Regeneron, US), tissue factor pathway inhibitors (EntreMed, US), tumor necrosis factor-alpha inhibitors, tumstatin, TZ 93, urokinase plasminogen activator inhibitors, vadimezan, vandetanib, vasostatin, vatalanib, VE-cadherin-2 antagonists, xanthorrhizol, XL 784 (Exelixis, US), ziv-aflibercept, and ZD 6126.

[0179]

The antitumor agent(s) that may be combined with formula (I) may also be an active agent that disrupts or inhibits RAS-RAF-ERK or PI3K-AKT-TOR signaling pathways or is a PD-1 and/or PD-L1 antagonist. Examples of which include, but are not limited to, a RAF inhibitor, an EGFR inhibitor, a MEK inhibitor, an ERK inhibitor, a PI3K inhibitor, an AKT inhibitor, a TOR inhibitor, an MCL-1 inhibitor, a BCL-2 inhibitor, a SHP2 inhibitor, a proteasome inhibitor, or an immune therapy, including monoclonal antibodies, immunomodulatory imides (IMiDs), anti-PD-1, anti-PD-L1, anti-CTLA4, anti-LAG1, and anti-OX40 agents, GITR agonists, CAR-T cells, and BiTEs.

[0180]

Non-limiting examples of RAF inhibitors include dabrafenib, encorafenib, regorafenib, sorafenib, and vemurafenib.

[0181]

Non-limiting examples of MEK inhibitors include binimetinib, CI-1040, cobimetinib, PD318088, PD325901, PD334581, PD98059, refametinib, selumetinib, and trametinib.

[0182]

Non-limiting examples of ERK inhibitors include LY3214996, LTT462, MK-8353, SCH772984, ravoxertinib, ulixertinib, and ASTX029.

[0183]

Non-limiting examples of PI3K inhibitors include 17-hydroxywortmannin analogs (*e.g.*, WO 06/044453); AEZS-136; alpelisib; AS-252424; buparlisib; CAL263;

copanlisib; CUDC-907; dactolisib (WO 06/122806); demethoxyviridin; duvelisib; GNE-477; GSK1059615; IC87114; idelalisib; INK1117; LY294002; Palomid 529; paxalisib; perifosine; PI-103; PI-103 hydrochloride; pictilisib (e.g., WO 09/036,082; WO 09/055,730); PIK 90; PWT33597; SF1126; sonolisib; TGI 00-115; TGX-221; XL147; XL-765; wortmannin; taselisib (GDC-0032); and ZSTK474.

[0184]

Non-limiting examples of AKT inhibitors include Akt-1-1 (inhibits Akt1) (Barnett *et al.* (2005) *Biochem. J.*, 385 (Pt. 2), 399-408); Akt-1-1,2 (Barnett *et al.* (2005) *Biochem. J.* 385 (Pt. 2), 399-408); API-59CJ-Ome (e.g., Jin *et al.* (2004) *Br. J. Cancer* 91, 1808-12); 1-H-imidazo[4,5-c]pyridinyl compounds (e.g., WO05/011700); indole-3-carbinol and derivatives thereof (e.g., U.S. Patent No. 6,656,963; Sarkar and Li (2004) *J Nutr.* 134(12 Suppl), 3493S-3498S); perifosine, (Dasmahapatra *et al.* (2004) *Clin. Cancer Res.* 10(15), 5242-52, 2004); phosphatidylinositol ether lipid analogues (e.g., Gills and Dennis (2004) *Expert. Opin. Investig. Drugs* 13, 787-97); triciribine (Yang *et al.* (2004) *Cancer Res.* 64, 4394-9); imidazooxazone compounds including trans-3-amino-1-methyl-3-[4-(3-phenyl-5H-imidazo[1,2-c]pyrido[3,4-e][1,3]oxazin-2-yl)phenyl]-cyclobutanol hydrochloride (WO 2012/137870) ; afuresertib; capivasertib; 8-[4-(1-aminocyclobutyl)phenyl]-9-phenyl-1,2,4-triazolo[3,4-f][1,6]naphthyridin-3(2H)-one (MK2206) and pharmaceutically acceptable salts thereof; AZD5363; trans-3-amino-1-methyl-3-(4-(3-phenyl-5H-imidazo[1,2-c]pyrido[3,4-e][1,3]oxazin-2-yl)phenyl)cyclobutanol (TAS-117) and pharmaceutically acceptable salts thereof; and patasertib.

[0185]

Non-limiting examples of TOR inhibitors include deforolimus; ATP-competitive TORC1/TORC2 inhibitors, including PI-103, PP242, PP30, and Torin 1; TOR inhibitors in FKBP12 enhancer, rapamycins and derivatives thereof, including temsirolimus, everolimus, WO 9409010; rapalogs, e.g. as disclosed in WO 98/02441 and WO 01/14387, e.g. AP23573, AP23464, or AP23841; 40-(2-hydroxyethyl)rapamycin, 40-[3-hydroxy(hydroxymethyl)methylpropanoate]-rapamycin; 40-epi-(tetrazolyl)-rapamycin (also called ABT578); AZD8055; 32-deoxorapamycin; 16-pentynyloxy-32(S)-dihydrorapamycin, and other derivatives disclosed in WO 05/005434; derivatives disclosed in US 5,258,389, WO 94/090101, WO 92/05179, US 5,118,677, US 5,118,678, US 5,100,883, US 5,151,413, US 5,120,842, WO 93/111130, WO 94/02136, WO 94/02485, WO 95/14023, WO 94/02136, WO 95/16691, WO 96/41807, WO 96/41807 and US 5,256,790; and phosphorus-containing rapamycin derivatives (e.g., WO 05/016252).

[0186]

Non-limiting examples of MCL-1 inhibitors include AMG-176, MIK665, and S63845.

[0187]

Non-limiting examples of SHP2 inhibitors include JAB-3068, RMC-4630, TNO155, SHP-099, RMC-4550, and SHP2 inhibitors described in WO 2019/167000, WO 2020/022323 and WO2021/033153.

[0188]

Non-limiting examples of RAS inhibitors include AMG510, MRTX849, LY3499446, JNJ-74699157 (ARS-3248), ARS-1620, ARS-853, RM-007, and RM-008.

[0189]

Additional non-limiting examples of antitumor agents that may be suitable for use include, but are not limited to, 2-ethylhydrazide, 2',2'-trichlorotriethylamine, ABVD, aceglatone, acemannan, aldophosphamide glycoside, alpharadin, amifostine, aminolevulinic acid, anagrelide, ANCER, aneastim, anti-CD22 immunotoxins, antitumorigenic herbs, apaziquone, arglabin, arsenic trioxide, azathioprine, BAM 002 (Novelos), bcl-2 (Genta), bestrabucil, biricodar, bisantrene, bromocriptine, brostallicin, bryostatin, buthionine sulfoximine, calyculin, cell-cycle nonspecific antineoplastic agents, celmoleukin, clodronate, clotrimazole, cytarabine ocfosfate, DA 3030 (Dong-A), defofamine, denileukin diftitox, dexrazoxane, diaziquone, dichloroacetic acid, dilazep, discodermolide, docosanol, doxercalciferol, edelfosine, eflornithine, EL532 (Elan), elfomithine, elsamitrucin, eniluracil, etanidazole, exisulind, ferruginol, folic acid replenisher such as frolinic acid, gacytosine, gallium nitrate, gimeracil/oteracil/tegafur combination (S-1), glycopine, histamine dihydrochloride, HIT diclofenac, HLA-B7 gene therapy (Vical), human fetal alpha fetoprotein, ibandronate, ibandronic acid, ICE chemotherapy regimen, imexon, iobenguane, IT-101 (CRLX101), laniquidar, LC 9018 (Yakult), leflunomide, lentinan, levamisole + fluorouracil, lovastatin, lucanthone, masoprocol, melarsoprol, metoclopramide, miltefosine, miproxifene, mitoguazone, mitozolomide, mopidamol, motexafin gadolinium, MX6 (Galderma), naloxone + pentazocine, nitracrine, nolatrexed, NSC 631570 octreotide (Ukrain), olaparib, P-30 protein, PAC-1, palifermin, pamidronate, pamidronic acid, pentosan polysulfate sodium, phenamet, picibanil, pixantrone, platinum, podophyllinic acid, porfimer sodium, PSK (Polysaccharide-K), rabbit antithymocyte polyclonal antibody, rasburiembodiment, retinoic acid, rhenium Re 186 etidronate, romurtide, samarium (153 Sm) lexidronam, sizofiran, sodium phenylacetate, sparfosic acid, spirogermanium, strontium-89 chloride, suramin, swainsonine, talaporfin, tariquidar, tazarotene, tegafur-uracil, temoporfin,

tenuazonic acid, tetrachlorodecaoxide, thrombopoietin, tin ethyl etiopurpurin, tirapazamine, TLC ELL-12, tositumomab-iodine 131, trifluridine and tipiracil combination, troponin I (Harvard University, US), urethan, valspodar, verteporfin, zoledronic acid, and zosuquidar.

[0190]

In the present description, the term "HER2" includes the HER2 of a human or a non-human mammal, and it is preferably human HER2. NCBI Gene ID of human HER2 is 2064. Furthermore, the term "HER2" includes isoforms.

[0191]

In the present description, the term "EGFR" includes the EGFR of a human or a non-human mammal, and it is preferably human EGFR. NCBI Gene ID of human EGFR is 1956. Furthermore, the term "EGFR" includes isoforms.

[0192]

The tumor that is the target of the present invention is not particularly limited as long as the antitumor agent exerts an antitumor effect thereon. Preferable is tumor on which a pyrimidine compound represented by the formula (I) or a salt thereof exerts an antitumor effect, and more preferable is malignant tumor associated with HER2 or malignant tumor associated with EGFR. In this context, the "malignant tumor associated with HER2" means malignant tumor, in which a reduction in the incidence, or the remission, alleviation and/or complete recovery of the symptoms thereof is achieved by deleting, suppressing and/or inhibiting the function of HER2. Such malignant tumor is preferably malignant tumor having HER2 overexpression, HER2 gene amplification, or HER2 mutation. In one embodiment, the "malignant tumor associated with HER2" is HER2-positive tumor. The "malignant tumor associated with EGFR" means malignant tumor, in which a reduction in the incidence, or the remission, alleviation and/or complete recovery of the symptoms thereof is achieved by deleting, suppressing and/or inhibiting the function of EGFR. Such malignant tumor is preferably malignant tumor having EGFR overexpression, EGFR gene amplification, or EGFR mutation. In one embodiment, the "malignant tumor associated with EGFR" is EGFR-positive tumor. In one embodiment, the tumor that is the target of the present invention is malignant tumor having HER2 overexpression, HER2 gene amplification, or HER2 mutation, or malignant tumor having EGFR overexpression, EGFR gene amplification, or EGFR mutation. In one embodiment, the tumor that is the target of the present invention is HER2-positive tumor or EGFR-positive tumor.

[0193]

One embodiment of the present invention provides an antitumor agent for

combined administration with other antitumor agent, the antitumor agent comprising the pyrimidine compound of the present invention or a salt thereof. One embodiment of the present invention provides an antitumor agent involving the combined administration of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent. One embodiment of the present invention provides a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent.

One embodiment of the present invention provides an antitumor agent for combined administration with other antitumor agent, the antitumor agent comprising the pyrimidine compound of the present invention or a salt thereof for the treatment of tumor. One embodiment of the present invention provides a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent for the treatment of tumor. One embodiment of the present invention provides use of a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent for the treatment of tumor. One embodiment of the present invention provides an antitumor agent involving the administration of the pyrimidine compound of the present invention or a salt thereof to a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) other antitumor agent. One embodiment of the present invention provides an antitumor agent involving the administration of other antitumor agent to a tumor patient given the pyrimidine compound of the present invention or a salt thereof or a tumor patient to be given (scheduled to be given) the pyrimidine compound of the present invention or a salt thereof.

In one embodiment of the present invention, the antitumor agent is orally administered.

One embodiment of the present invention provides use of the pyrimidine compound of the present invention or a salt thereof for the production of a medicament that is used in combination with other antitumor agent in the treatment of tumor. One embodiment of the present invention provides use of other antitumor agent for the production of a medicament that is used in combination with the pyrimidine compound of the present invention or a salt thereof in the treatment of tumor. One embodiment of the present invention provides use of a combination of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent for the production of a

medicament in the treatment of tumor.

One embodiment of the present invention provides an antitumor effect potentiator for potentiating the antitumor effect of other antitumor agent, the antitumor effect potentiator containing the pyrimidine compound of the present invention or a salt thereof.

One embodiment of the present invention provides the pyrimidine compound of the present invention or a salt thereof, or use of the pyrimidine compound of the present invention or a salt thereof for use in the treatment of tumor involving combined use with other antitumor agent. One embodiment of the present invention provides other antitumor agent, or use of other antitumor agent for use in the treatment of tumor involving combined use with the pyrimidine compound of the present invention or a salt thereof. One embodiment of the present invention provides the pyrimidine compound of the present invention or a salt thereof, or use of the pyrimidine compound of the present invention or a salt thereof for treating a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) other antitumor agent. One embodiment of the present invention provides other antitumor agent, or use of other antitumor agent for treating a tumor patient given the pyrimidine compound of the present invention or a salt thereof or a tumor patient to be given (scheduled to be given) the pyrimidine compound of the present invention or a salt thereof.

One embodiment of the present invention provides a combination antitumor agent involving the combined administration of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent. One embodiment of the present invention provides a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent, wherein the pyrimidine compound or the salt thereof and the other antitumor agent are administered concurrently, sequentially, or at an interval in the treatment of tumor.

One embodiment of the present invention provides the pyrimidine compound of the present invention or a salt thereof for potentiating the antitumor effect of other antitumor agent. One embodiment of the present invention provides use of the pyrimidine compound of the present invention or a salt thereof for potentiating the antitumor effect of other antitumor agent.

One embodiment of the present invention provides a method for treating tumor, comprising the step of administering a therapeutically effective amount of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent in combination to a patient. One embodiment of the present invention provides a method

for treating tumor, comprising the step of administering an effective amount of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent to a patient in need thereof. One embodiment of the present invention provides a method for treating tumor, comprising administering an effective amount of a combination (pharmaceutical combination or combination product) of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent to a patient in need thereof. One embodiment of the present invention provides a method for treating tumor, comprising the step of administering a therapeutically effective amount of the pyrimidine compound of the present invention or a salt thereof to a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) other antitumor agent. One embodiment of the present invention provides a method for treating tumor by combined use with other antitumor agent, comprising administering an effective amount of the pyrimidine compound of the present invention or a salt thereof to a patient in need thereof.

One embodiment of the present invention provides a pharmaceutical composition for the treatment of tumor, comprising the pyrimidine compound of the present invention or a salt thereof and other antitumor agent.

One embodiment of the present invention provides a method for treating tumor, or a method for potentiating an antitumor effect, comprising the step of administering a therapeutically effective amount of other antitumor agent to a tumor patient given the pyrimidine compound of the present invention or a salt thereof or a tumor patient to be given (scheduled to be given) the pyrimidine compound of the present invention or a salt thereof. One embodiment of the present invention provides a method for potentiating an antitumor effect, comprising the step of administering a therapeutically effective amount of the pyrimidine compound of the present invention or a salt thereof to a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) the pyrimidine compound of the present invention or a salt thereof.

[0194]

One embodiment of the present invention provides an antitumor agent for combined administration with other antitumor agent, the antitumor agent comprising 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof. One embodiment of the present invention provides an antitumor agent involving the combined administration of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent. One embodiment of the present

invention provides a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent.

One embodiment of the present invention provides an antitumor agent for combined administration with other antitumor agent, the antitumor agent comprising 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof for the treatment of tumor. One embodiment of the present invention provides a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent for the treatment of tumor. One embodiment of the present invention provides use of a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent for the treatment of tumor. One embodiment of the present invention provides an antitumor agent involving the administration of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof to a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) other antitumor agent. One embodiment of the present invention provides an antitumor agent involving the administration of other antitumor agent to a tumor patient given 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof or a tumor patient to be given (scheduled to be given) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof.

In one embodiment of the present invention, the antitumor agent is orally administered.

One embodiment of the present invention provides use of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof for the production of a medicament that is used in combination with other antitumor agent in the treatment of tumor. One embodiment of the present invention provides use of other antitumor agent

for the production of a medicament that is used in combination with 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof in the treatment of tumor. One embodiment of the present invention provides use of a combination of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent for the production of a medicament in the treatment of tumor.

One embodiment of the present invention provides an antitumor effect potentiator for potentiating the antitumor effect of other antitumor agent, the antitumor effect potentiator containing 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof.

One embodiment of the present invention provides 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof, or use of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof for use in the treatment of tumor involving combined use with other antitumor agent. One embodiment of the present invention provides other antitumor agent, or use of other antitumor agent for use in the treatment of tumor involving combined use with 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof. One embodiment of the present invention provides 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof, or use of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof for treating a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) other antitumor agent. One embodiment of the present invention provides other antitumor agent, or use of other antitumor agent for treating a tumor patient given 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof or a tumor patient to be given (scheduled to be given) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof.

One embodiment of the present invention provides a combination antitumor agent involving the combined administration of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent. One embodiment of the present invention provides a combination (pharmaceutical combination, combination method, combination product, or therapeutic combination) of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent, wherein the compound or the salt thereof and the other antitumor agent are administered concurrently, sequentially, or at an interval in the treatment of tumor.

One embodiment of the present invention provides 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof for potentiating the antitumor effect of other antitumor agent. One embodiment of the present invention provides use of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof for potentiating the antitumor effect of other antitumor agent. One embodiment of the present invention provides use of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof for potentiating the antitumor effect of other antitumor agent.

One embodiment of the present invention provides a method for treating tumor, comprising the step of administering a therapeutically effective amount of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent in combination to a patient. One embodiment of the present invention provides a method for treating tumor, comprising the step of administering an effective amount of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent to a patient in need thereof. One embodiment of the present invention provides a method for treating tumor, comprising administering an effective amount of a combination (pharmaceutical combination or combination product) of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent to a patient in need thereof. One embodiment of the present invention provides a method for treating tumor, comprising

the step of administering a therapeutically effective amount of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof to a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) other antitumor agent. One embodiment of the present invention provides a method for treating tumor by combined use with other antitumor agent, comprising administering an effective amount of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof to a patient in need thereof.

One embodiment of the present invention provides a pharmaceutical composition for the treatment of tumor, comprising 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof and other antitumor agent.

One embodiment of the present invention provides a method for treating tumor, or a method for potentiating an antitumor effect, comprising the step of administering a therapeutically effective amount of other antitumor agent to a tumor patient given 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof or a tumor patient to be given (scheduled to be given). One embodiment of the present invention provides a method for potentiating an antitumor effect, comprising the step of administering a therapeutically effective amount of 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide or a salt thereof to a tumor patient given other antitumor agent or a tumor patient to be given (scheduled to be given) other antitumor agent.

[0195]

One embodiment of the present invention provides an antitumor agent for use in the treatment of malignant tumor associated with HER2, wherein other antitumor agent that is used in combination with the pyrimidine compound of the present invention or a salt thereof is at least one antimetabolite, Her2 inhibitor, PI3K/AKT/mTOR inhibitor, CDK4/6 inhibitor, estrogen receptor antagonist, platinum drug, or vegetable alkaloid drug.

One embodiment of the present invention provides an antitumor agent for use in the treatment of malignant tumor associated with EGFR, wherein other antitumor agent that is used in combination with the pyrimidine compound of the present invention or a salt thereof is at least one antimetabolite, PI3K/AKT/mTOR inhibitor, CDK4/6 inhibitor, estrogen receptor antagonist, platinum drug, or vegetable alkaloid drug.

[0196]

The antitumor agent of the present invention may be used in postoperative adjuvant chemotherapy which is performed for preventing recurrence after surgical removal of tumor, or may be used in preoperative adjuvant chemotherapy which is performed for surgically removing tumor.

[0197]

The wild-type human HER2 gene is shown in, for example, SEQ ID NO: 1. The wild-type HER2 protein consists of the amino acid sequence set forth in, for example, SEQ ID NO: 2. The nucleotide sequence information of the human HER2 gene can be obtained from, for example, Accession No. NM_004448, or the like and the amino acid sequence information of the wild-type HER2 protein can be obtained from, for example, Accession No. NP_004439, or the like.

[0198]

In several embodiments, the pyrimidine compound of the present invention or a salt thereof exhibits inhibitory activity against mutant HER2 comprising one or more mutations from G309A, S310F, R678Q, L755S, L755_T759del, D769H, A775_G776insYVMA, V777L, V842I and R896C, using the amino acid sequence set forth in SEQ ID NO: 2 as a reference. In another embodiment, the pyrimidine compound of the present invention or a salt thereof exhibits inhibitory activity against mutant HER2 comprising A775_G776insYVMA, using the amino acid sequence set forth in SEQ ID NO: 2 as a reference.

[0199]

Further, in several embodiments, with regard to a mutation in a certain HER2 isoform, even when the position of the mutation is different from the position of an amino acid shown in SEQ ID NO: 2 due to deletion or insertion of an amino acid(s), it is understood that the mutation is the same as the mutation at a position corresponding to the position of the amino acid shown in SEQ ID NO: 2. Hence, for example, the glycine at position 309 in the HER2 shown in SEQ ID NO: 2 corresponds to glycine at position 294 in HER2 consisting of the amino acid sequence set forth in SEQ ID NO: 4. For example, the term "G309A" means that the glycine at position 309 in the HER2 shown in SEQ ID NO: 2 is mutated to alanine. Since such "G309" is at a position corresponding to the amino acid at position 294 in HER2 consisting of the amino acid sequence set forth in SEQ ID NO: 4, "G294A" in the HER2 consisting of the amino acid sequence set forth in SEQ ID NO: 4 corresponds to "G309A" in the HER2 shown in SEQ ID NO: 2. Besides, the position of an amino acid in SEQ ID NO: 2 that corresponds to a certain amino acid in a certain HER2 isoform can be confirmed by Multiple Alignment of BLAST.

[0200]

Sequence Listing

[Table A]

SEQ ID NO: 1
Accession No.: NM_004448
CDS: 262..4029
<p>1 gcttgctccc aatcacagga gaaggaggag gtggaggagg agggctgctt gaggaagtat</p> <p>61 aagaatgaag ttgtgaagct gagattcccc tccattggga ccggagaaac caggggagcc</p> <p>121 ccccgggcag ccgcgcgccc ctccccacgg ggccctttac tgcgcgcgcg gcccgcccc</p> <p>181 caccctcgc agcaccgccg gccccgcgcg ctcccagccg ggtccagccg gagccatggg</p> <p>241 gccggagccg cagtgagcac catggagctg gcggccttgt gccgctgggg gctcctcctc</p> <p>301 gccctcttgc cccccggagc cgcgagcacc caagtgtgca ccggcacaga catgaagctg</p> <p>361 cggtccctg ccagtcgccg gaccacctg gacatgctcc gccacctcta ccagggtgc</p> <p>421 caggtggtgc agggaaacct ggaactcacc tacctgcccc ccaatgccag cctgtccttc</p> <p>481 ctgcaggata tccaggaggt gcagggctac gtgctcatcg ctcaacaaca agtgaggcag</p> <p>541 gtcccaactgc agaggctgcg gattgtgcga ggcaccacgc tctttgagga caactatgcc</p> <p>601 ctggcctgct tagacaatgg agaccgcgtg aacaatacca ccctgtcac aggggcctcc</p> <p>661 ccaggaggcc tgcgggagct gcagcttcga agcctcacag agatcttgaa aggaggggtc</p> <p>721 ttgatccagc ggaacccccca gctctgctac caggacacga ttttgtggaa ggacatcttc</p> <p>781 cacaagaaca accagctggc tctcacaactg atagacacca accgctctcg ggctgccac</p> <p>841 ccctgttctc cgatgtgtaa gggctccgcg tgctggggag agagtcttga ggattgtcag</p> <p>901 agcctgacgc gcaactgtctg tgccggtggc tgtgcccgt gcaaggggcc actgccact</p> <p>961 gactgctgcc atgagcagtg tgctgccggc tgcacgggcc ccaagcactc tgactgctg</p> <p>1021 gcctgcctcc acttcaacca cagtggcctc tgtgagctgc actgcccagc cctggtcacc</p> <p>1081 tacaacacag acacgtttga gtccatgcc aatcccgagg gccggtatac attcggcgcc</p> <p>1141 agctgtgtga ctgcctgtcc ctacaactac ctttctacgg acgtgggatc ctgcaccctc</p> <p>1201 gtctgcccc tgcacaacca agaggtgaca gcagaggatg gaacacagcg gtgtgagaag</p> <p>1261 tgcagcaagc cctgtgcccg agtgtgctat ggtctgggca tggagcactt gcgagaggtg</p> <p>1321 agggcagtta ccagtgccaa tatccaggag tttgctggct gcaagaagat ctttgggagc</p> <p>1381 ctggcatttc tgccggagag ctttcatggg gaccacgct ccaacactgc cccgctccag</p> <p>1441 ccagagcagc tccaagtgtt tgagactctg gaagagatca caggttacct atacatctca</p> <p>1501 gcatggcccg acagcctgcc tgacctcagc gtcttccaga acctgcaagt aatccgggga</p> <p>1561 cgaattctgc acaatggcgc ctactcgtg acctgcaag ggctgggcat cagctggctg</p> <p>1621 gggctgcgct cactgagggg actgggcagt ggactggccc tcatccacca taacaccac</p> <p>1681 ctctgcttcg tgcacacggt gccctgggac cagctctttc ggaacccgca ccaagctctg</p> <p>1741 ctccacactg ccaaccggcc agaggacgag tgtgtgggcg agggcctggc ctgccaccag</p> <p>1801 ctgtgcgccc gagggcactg ctgggggtcca gggccaccc agtgtgtcaa ctgcagccag</p>

1861 ttcccttcggg gccaggagtg cgtggaggaa tgccgagtag tgcaggggct cccaggggag
 1921 tatgtgaatg ccaggcactg tttgccgtgc caccctgagt gtcagcccca gaatggctca
 1981 gtgacctgtt ttggaccgga ggctgaccag tgtgtggcct gtgccacta taaggaccct
 2041 cccttctgcg tggcccgctg cccagcggt gtgaaacctg acctctccta catgccatc
 2101 tggaagtttc cagatgagga gggcgcatgc cagccttgcc ccatcaactg caccactcc
 2161 tgtgtggacc tggatgacaa gggctgcccc gccgagcaga gagccagccc tctgacgtcc
 2221 atcatctctg cggtgggttg cattctgctg gtcgtggtct tgggggtggc ctttgggatc
 2281 ctcatcaagc gacggcagca gaagatccgg aagtacacga tgcggagact gctgcaggaa
 2341 acggagctgg tggagccgct gacacctagc ggagcgatgc ccaaccaggc gcagatgcgg
 2401 atcctgaaag agacggagct gaggaaggtg aaggtgcttg gatctggcgc ttttggcaca
 2461 gtctacaagg gcatctggat ccctgatggg gagaatgtga aaattccagt ggccatcaaa
 2521 gtgttgaggg aaaacacatc ccccaaagcc aacaaagaaa tcttagacga agcatacgtg
 2581 atggctggtg tgggctcccc atatgtctcc cgccttctgg gcatctgcct gacatccacg
 2641 gtgcagctgg tgacacagct tatgccctat ggctgcctct tagaccatgt ccgggaaaac
 2701 cgcggacgcc tgggctccca ggacctgctg aactggtgta tgcagattgc caaggggatg
 2761 agctacctgg aggatgtgcg gctcgtagac agggacttgg ccgctcgga cgtgctggtc
 2821 aagagtccca accatgtcaa aattacagac ttcgggctgg ctcggtgct ggacattgac
 2881 gagacagagt accatgcaga tgggggcaag gtgcccatca agtggatggc gctggagtcc
 2941 attctccgcc ggcggttcac ccaccagagt gatgtgtgga gttatggtgt gactgtgtgg
 3001 gagctgatga cttttggggc caaaccttac gatgggatcc cagcccggga gatccctgac
 3061 ctgctggaaa agggggagcg gctgccccag ccccccactc gcaccattga tgtctacatg
 3121 atcatggtca aatgttggat gattgactct gaatgtcggc caagattccg ggagttgggtg
 3181 tctgaattct cccgcatggc cagggacccc cagcgctttg tggcatcca gaatgaggac
 3241 ttgggcccag ccagtccctt ggacagcacc ttctaccgct cactgctgga ggacgatgac
 3301 atgggggacc tgggtgatgc tgaggagtat ctggtacccc agcagggctt cttctgtcca
 3361 gacctgccc cgggcgctgg gggcatggtc caccacaggc accgcagctc atctaccagg
 3421 agtggcggtg gggacctgac actagggctg gagccctctg aagaggaggc cccaggtct
 3481 ccaactggcac cctccgaagg ggctggctcc gatgtatttg atggtgacct gggaatgggg
 3541 gcagccaagg ggctgcaaag cctccccaca catgaccca gccctctaca gcggtacagt
 3601 gaggacccca cagtaccctt gccctctgag actgatggct acgttgcccc cctgacctgc
 3661 agccccagc ctgaatatgt gaaccagcca gatgttcggc ccagccccc ttcgccccga
 3721 gagggccctc tgctgctgc ccgacctgct ggtgccactc tggaaaggcc caagactctc
 3781 tccccaggga agaattgggt cgtcaaagac gtttttgctt ttgggggtgc cgtggagaac
 3841 cccgagtact tgacacccca gggaggagct gccctcagc cccacctcc tctgccttc
 3901 agcccagcct tcgacaacct ctattactgg gaccaggacc caccagagcg gggggctcca
 3961 cccagcacct tcaaagggac acctacggca gagaaccag agtacctggg tctggacgtg

4021	ccagtgtgaa ccagaagggc aagtccgcag aagccctgat gtgtcctcag ggagcagggg	
4081	aggcctgact tctgctggca tcaagaggtg ggagggccct ccgaccactt ccaggggaac	
4141	ctgccatgcc aggaacctgt cctaaggaac cttccttcct gcttgagttc ccagatggct	
4201	ggaaggggtc cagcctcggtt ggaagaggaa cagcactggg gagtctttgt ggattctgag	
4261	gccctgccc aatgagactct aggggtccagt ggatgccaca gccagcttg gccctttcct	
4321	tccagatcct ggggtactgaa agccttaggg aagctggcct gagaggggaa gcggccctaa	
4381	gggagtgtct aagaacaaaa gcgaccatt cagagactgt ccctgaaacc tagtactgcc	
4441	ccccatgagg aaggaacagc aatgggtgtca gtatccaggc tttgtacaga gtgcttttct	
4501	gttttagtttt tactttttttt gttttgtttt tttaaagatg aaataaagac ccagggggag	
4561	aatgggtgtt gtatggggag gcaagtgtgg ggggtccttc tccacacca ctttgtccat	
4621	ttgcaaatat attttggaac acagctaaaa aaaaaaaaaa aaaa	
SEQ ID NO: 2		
Accession No.: NM_004448		
MELAALCRWG	LLLALLPPGA ASTQVCTGTD MKLRLPASPE THLDMLRHLY QGCQVVQGNL	60
ELTYLPTNAS	LSFLQDIQEV QGYVLIAHNQ VRQVPLQRLR IVRGTQLFED NYALAVLDNG	120
DPLNNTTPVT	GASPGGLREL QLRSLTEILK GGVLIQRNPQ LCYQDTILWK DIFHKNNQLA	180
LTLIDTNRSR	ACHPCSPMCK GSRCWGESSE DCQSLTRTVC AGGCARCKGP LPTDCCHEQC	240
AAGCTGPKHS	DCLACLHFNH SGICELHCPA LVTYNTDTFE SMPNPEGRTY FGASCVTACP	300
YNYLSTDVGS	CTLVCPLHNQ EVTAEDGTQR CEKCSKPCAR VCYGLGMEHL REVRAVTSAN	360
IQEFAGCKKI	FGSLAFLPES FDGDPASNTA PLQPEQLQVF ETLEEITGYL YISAWPDSLP	420
DLSVFQNLQV	IRGRILHNGA YSLTLQGLGI SWLGLRSLRE LGSGLALIIH NTHLCFVHTV	480
PWDQLFRNPH	QALLHTANRP EDECVGEGLA CHQLCARGHC WGPGPQTQCVN CSQFLRGQEC	540
VEECRVLQGL	PREYVNARHC LPCHPECQPQ NGSVTCFGPE ADQCVACAHY KDPPFCVARC	600
PSGVKPDLSY	MPIWKFPDEE GACQPCPINC THSCVDLDDK GCPAEQRASP LTSIISAVVG	660
ILLVVVLGVV	FGILIKRRQQ KIRKYTMRL LQETELVEPL TPGAMPNQA QMRILKETEL	720
RKVKVLGSGA	FGTVYKGIWI PDGENVKIPV AIKVLRENTS PKANKEILDE AYVMAGVGSP	780
YVSRLLGICL	TSTVQLVTQL MPYGCLLDHV RENRGRIGSQ DLLNWCMQIA KGMSYLEDVR	840
LVHRDLAARN	VLVKSPNHVK ITDFGLARLL DIDETEHYHAD GGVKPIKWMA LESILRRRFT	900
HQSDVWSYGV	TVWELMTFGA KPYDGIPARE IPDLLEKGER LPQPPICTID VYMIMVKCWM	960
IDSECRPRFR	ELVSEFSRMA RDPQRFVVIQ NEDLGPASPL DSTFYRSLLE DDDMGDLVDA	1020
EEYLVPQQGF	FCPDPAAGAG GMVHHRHRSS STRSGGGDLT LGLEPSEEEA PRSPLAPSEG	1080
AGSDVFDGDL	GMGAAGGLQS LPTHDPSPLO RYSEDPTVPL PSETDGYVAP LTCSPQPEYV	1140
NQPDVRPQPP	SPREGPLPAA RPAGATLERP KTLSPGKNGV VKDVFAFGGA VENPEYLTPQ	1200
GGAAPQPHPP	PAFSPAFDNL YYWDQDPPER GAPPSTFKGT PTAENPEYLG LDVPV	1255

SEQ ID NO: 3

Accession No.: NM_001289936

CDS: 583..4305

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1 aagttcctgt gttctttatt ctactctccg ctgaagtcca cacagtttaa attaaagttc
61 ccggaattttt gtgggcgcct gccccgcccc tcgtccccct gctgtgtcca tatatcgagg
121 cgataggggtt aaggggaaggc ggacgcctga tgggttaatg agcaaactga agtgttttcc
181 atgatctttt ttgagtcgca attgaagtac cacctcccga gggtgattgc ttccccatgc
241 ggggtagaac ctttgctgtc ctgttcacca ctctacctcc agcacagaat ttggcttatg
301 cctactcaat gtgaagatga tgaggatgaa aacctttgtg atgatccact tccacttaat
361 gaatggtggc aaagcaaagc tatattcaag accacatgca aagctactcc ctgagcaaag
421 agtcacagat aaaacggggg caccagtaga atggccagga caaacgcagt gcagcacaga
481 gactcagacc ctggcagcca tgccctgcgc ggcagtgatg agagtgcacat gtactgttgt
541 ggacatgcac aaaagtgaga tacttcaaag attccagaag atatgccccg ggggtcctgg
601 aagccacaag tgtgcaccgg cacagacatg aagctgcggc tccctgccag tcccgagacc
661 cacctggaca tgctccgcca cctctaccag ggctgccagg tgggtgcagg aaacctggaa
721 ctccactacc tgcccaccaa tgccagcctg tccttcctgc aggatatcca ggaggtgcag
781 ggctacgtgc tcctcgtc caaccaagtg aggcaggctc cactgcagag gctgcggatt
841 gtgcgaggca cccagctctt tgaggacaac tatgccctgg ccgtgctaga caatggagac
901 ccgctgaaca ataccacccc tgtcacaggg gcctccccag gaggcctgcg ggagctgcag
961 cttcgaagcc tcacagagat cttgaaagga ggggtcttga tccagcggaa cccccagctc
1021 tgctaccagg acacgatttt gtggaaggac atcttcaca agaacaacca gctggctctc
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1141 tcccgtgct ggggagagag ttctgaggat tgtcagagcc tgacgcgcac tgtctgtgcc
1201 ggtggctgtg cccgtgcaa ggggccactg cccactgact gctgccatga gcagtgtgct
1261 gccggctgca cgggccccaa gcactctgac tgccctggcct gcctccactt caaccacagt
1321 ggcactctgtg agctgcactg cccagccctg gtcacctaca acacagacac gtttgagtcc
1381 atgcccacac ccgagggccg gtatacattc ggcgccagct gtgtgactgc ctgtccctac
1441 aactaccttt ctacggacgt gggatcctgc accctcgtct gccccctgca caaccaagag
1501 gtgacagcag aggatggaac acagcgggtg gagaagtga gcaagccctg tgcccagtg
1561 tgctatggtc tgggcatgga gcacttgoga gaggtgaggg cagttaccag tgccaatatc
1621 caggagtttg ctggctgcaa gaagatcttt gggagcctgg catttctgcc ggagagcttt
1681 gatggggacc cagcctccaa cactgccccg ctccagccag agcagctcca agtgtttgag
1741 actctggaag agatcacagg ttacctatac atctcagcat ggccggacag cctgcctgac
1801 ctccagcgtc tccagaacct gcaagtaatc cggggacgaa ttctgcacaa tggcgcctac
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1861 tcgctgaccc tgcaagggct gggcatcagc tggctggggc tgcgctcact gagggaaactg
1921 ggcagtggac tggccctcat ccaccataac acccacctct gcttcgtgca cacggtgccc
1981 tgggaccagc tctttcggaa cccgcaccaa gctctgctcc aactgccaa ccggccagag
2041 gacgagtgtg tgggcgaggg cctggcctgc caccagctgt gcgcccagag gcactgctgg
2101 ggtccagggc ccaccagtg tgtcaactgc agccagttcc ttcggggcca ggagtgcgtg
2161 gaggaatgcc gactactgca ggggctcccc agggagtatg tgaatgccag gcactgtttg
2221 ccgtgccacc ctgagtgtca gcccagaat ggctcagtga cctgttttgg accggaggct
2281 gaccagtgtg tggcctgtgc cactataag gaccctccct tctgctggc ccgctgcccc
2341 agcgggtgtg aacctgacct ctctacatg cccatctgga agtttccaga tgaggagggc
2401 gcatgccagc cttgccccat caactgcacc cactcctgtg tggacctgga tgacaagggc
2461 tgccccgcgc agcagagagc cagccctctg acgtccatca tctctgcggt ggttggcatt
2521 ctgctggctg tggctttggg ggtggtcttt gggatcctca tcaagcgacg gcagcagaag
2581 atccggaagt acacgatgcg gagactgctg caggaaacgg agctggtgga gccgctgaca
2641 cctagcggag cgatgcccac ccaggcgag atgcggatcc tgaaagagac ggagctgagg
2701 aaggtgaagg tgcttgatc tggcgctttt ggcacagtct acaagggcat ctggatccct
2761 gatggggaga atgtgaaaat tccagtggcc atcaaagtgt tgagggaaaa cacatcccc
2821 aaagccaaca aagaaatctt agacgaagca tacgtgatgg ctggtgtggg ctccccatat
2881 gtctcccgcc ttctgggcat ctgcctgaca tccacggtgc agctggtgac acagcttatg
2941 ccctatggct gcctcttaga ccatgtccgg gaaaaccgcg gacgcctggg ctcccaggac
3001 ctgctgaact ggtgtatgca gattgccaag gggatgagct acctggagga tgtgctggctc
3061 gtacacaggg acttgccgc tcggaacgtg ctggtcaaga gtcccaacca tgtcaaaatt
3121 acagacttcg ggctggctcg gctgctggac attgacgaga cagagtacca tgcatgagg
3181 ggcaaggtgc ccatcaagtg gatggcgtg gagtccattc tccgccggcg gttcaccac
3241 cagagtgatg tgtggagtta tgggtgtgact gtgtgggagc tgatgacttt tggggccaaa
3301 ccttacgatg ggatcccagc ccgggagatc cctgacctgc tggaaaaggg ggagcggctg
3361 cccagcccc ccatctgcac cattgatgtc tacatgatca tgggtcaaag ttggatgatt
3421 gactctgaat gtggccaag attccgggag ttggtgtctg aattctccc catggccagg
3481 gacccccagc gctttgtggt catccagaat gaggacttgg gccagccag tcccttgac
3541 agcaccttct accgctcact gctggaggac gatgacatgg gggacctggg ggatgctgag
3601 gagtatctgg taccacagca gggcttcttc tgtccagacc ctgccccggg cgctgggggc
3661 atggtccacc acaggcaccg cagctcatct accaggagtg gcggtgggga cctgacacta
3721 gggctggagc cctctgaaga ggaggcccc aggtctccac tggcaccctc cgaaggggct
3781 ggctccgatg tatttgatgg tgacctggga atgggggcag ccaaggggct gcaaagcctc
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3901 tctgagactg atggtacgt tgccccctg acctgcagcc cccagcctga atatgtgaac
3961 cagccagatg ttgggcccc gcccccttcg ccccgagagg gccctctgcc tgctgcccga

4021 cctgctggtg ccactctgga aaggcccaag actctctccc caggaagaa tggggtcgtc
 4081 aaagacgttt ttgccttttg ggggtgccgtg gagaaccccg agtacttgac accccagga
 4141 ggagctgccc ctacagcccca cctcctcct gccttcagcc cagccttoga caacctctat
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 4261 acggcagaga acccagagta cctgggtctg gacgtgccag tgtgaaccag aaggccaagt
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 4681 cccattcaga gactgtccct gaaacctagt actgcccccc atgaggaagg aacagcaatg
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 4801 tgttttttta aagatgaaat aaagaccag ggggagaatg ggtgttgtat ggggagga
 4861 gtgtgggggg tccttctcca ccccacttt gtccatttgc aaatatattt tggaaaacag
 4921 ctaaaaaaaaa aaaaaaaaaa

SEQ ID NO: 4

Accession No.: NM_001289936

MPRGSWKPV CTGTMKLRL PASPETHLDM LRHLYQGCQV VQGNLELTYL PTNASLSFLQ 60
 DIQEVQGYVL IAHNQVRQVP LQRLRIVRGT QLFEDNYALA VLDNGDPLNN TTPVTGASPG 120
 GLRELQLRSL TEILKGGVLI QRNPQLCYQD TILWKDIFHK NNQLALTLID TNRSRACHPC 180
 SPMCKGSRW GESSEDCQSL TRTVCAGGCA RCKGPLPTDC CHEQCAAGCT GPKHSDCLAC 240
 LHFNHSGICE LHCPALVTYN TDTFESMPNP EGRYTFGASC VTACPYNLYS TDVGSCTLVC 300
 PLHNQEVTA EGTQRCEKCS KPCARVCYGL GMEHLREVRA VTSANIQEFA GCKKIFGSLA 360
 FLPESFDGDP ASNTAPLQPE QLQVFETLEE ITGYLYISAW PDSLPLDSVF QNLQVIRGRI 420
 LHNGAYSLTL QGLGISWLGL RSLRELGSGL ALIHHNTHLC FVHTVPWDQL FRNPHQALLH 480
 TANRPEDECV GEGLACHQLC ARGHCWGP GP TQCVNCSQFL RGQECVEECR VLQGLPREYV 540
 NARHCLPCHP ECQPQNGSVT CFGPEADQCV ACAHYKDPPF CVARCPSGVK PDLSPYPIWK 600
 FPDEEGACQP CPINCTHSCV DLDDKGCPAE QRASPLTSII SAVVGILLVV VLGVVFGILI 660
 KRRQQKIRKY TMRRLQETE LVEPLTPSGA MPNQAQMRIL KETELRKVKV LGSGAFGTVY 720
 KGIWIPDGEN VKIPVAIKVL RENTSPKANK EILDEAYVMA GVGSPYVSRL LGICLTSTVQ 780
 LVTQLMPYGC LLDHVRENRG RLGSQDLLNW CMQIAKGMSY LEDVRLVHRD LAARNVLVKS 840
 PNHVKITDFG LARLLDIDET EYHADGGKVP IKWMALESIL RRRFTHQSDV WSYGVTWVWL 900
 MTFGAKPYDG IPAREIPDLL EKGERLPQPP ICTIDVYMIM VKCWMIDSEC RPRFRELVSE 960

FSRMARDPQR	FVVIQNE	DLG	PASPLD	STFY	RSLL	EDDD	DMG	DLVDA	E EYL	LV	PQGG	FFC	PDP	1020
APGAGGMVHH	RHRSS	STRSG	GGDL	TLGLE	P	SEEE	APRS	PL	APSEG	AGSDV	FDGD	LGM	GAA	1080
KGLQSLPTH	D	PSPLQ	RYSED	PTVPL	PSETD	GYVAP	LTCS	P	QPEY	VNQPDV	RPQP	PPSP	REG	1140
PLPAARPAGA	TLERPK	TLSP	GKNG	VVKD	V	AFGG	AVEN	PE	YLTP	QGG	AAP	QPHPP	PAFSP	1200
AFDNL	YYWDQ		DPPER	GAPPS		TFKGT	PTAEN		PEYL	GLD	V	PV		
1240														

[0201]

The human wild-type EGFR gene is shown in, for example, SEQ ID NO: 5. The human wild-type EGFR protein consists of the amino acid sequence set forth in, for example, SEQ ID NO: 6. The nucleotide sequence information of the human wild-type EGFR gene can be obtained from, for example, NCBI Reference Sequence: NM_005228, or the like. and the amino acid sequence information of the human wild-type EGFR protein can be obtained from, for example, NCBI Reference Sequence: NP_005219, , or the like.

[0202]

In several embodiments, the pyrimidine compound of the present invention or a salt thereof exhibits inhibitory activity against mutant EGFR. In the present description, "mutant EGFR" is EGFR having one or more activating mutations or resistance acquiring mutations, such as insertion mutations point mutations, or deletion mutations, in exon 18 region, exon 19 region, exon 20 region, exon 21 region or the like of human wild-type EGFR.

[0203]

In the present description, "exon 18" corresponds to a region from positions 688 to 728 in the amino acid sequence of the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6).

[0204]

In the present invention, "exon 18 mutation" refers to a point mutation or a deletion mutation in exon 18 region resulting in an amino acid mutation in the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6). Examples of the point mutation in exon 18 include point mutation E709X or G719X in exon 18 region, which substitutes glutamic acid at position 709 or glycine at position 719 with any amino acid. Examples of E709X include point mutation E709K in exon 18 region, which substitutes glutamic acid at position 709 with lysine, and point mutation E709A in exon 18 region, which substitutes glutamic acid at

position 709 with alanine. Examples of G719X include point mutation G719A in exon 18 region, which substitutes glycine at position 719 with alanine, point mutation G719S in exon 18 region, which substitutes glycine at position 719 with serine, and point mutation G719C in exon 18 region, which substitutes glycine at position 719 with cysteine. The deletion mutation in exon 18 region encompasses not only a mutation in exon 18 region, which deletes some amino acids, but also a mutation therein, which inserts any one or more amino acids in addition to the amino acid deletion. Examples of the deletion mutation in exon 18 include a mutation in exon 18 region, which deletes glutamic acid at position 709 and threonine at position 710 and then inserts aspartic acid (Del E709-T710insD).

[0205]

In the present description, "exon 19" corresponds to a region from positions 729 to 761 in the amino acid sequence of the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6).

[0206]

In the present description, "exon 19 mutation" refers to a mutation in exon 19 region, which deletes one or more amino acids in the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6). The deletion mutation in exon 19 region encompasses not only a mutation in exon 19 region, which deletes some amino acids, but also a mutation therein, which inserts any one or more amino acids in addition to the amino acid deletion. Examples of the exon 19 deletion mutation include a mutation in exon 19 region, which deletes 5 amino acids from glutamic acid at position 746 to alanine at position 750 (Del E746-A750 (or also referred to as d746-750)), a mutation in exon 19 region, which deletes 7 amino acids from leucine at position 747 to proline at position 753 and then inserts serine (Del L747-P753insS), a mutation in exon 19 region, which deletes 5 amino acids from leucine at position 747 to threonine at position 751 (Del L747-T751), and a mutation in exon 19 region, which deletes 4 amino acids from leucine at position 747 to alanine at position 750 and then inserts proline (Del L747-A750insP). In one preferred embodiment of the present invention, the exon 19 deletion mutation is a mutation in exon 19 region, which deletes 5 amino acids from glutamic acid at position 746 to alanine at position 750 (Del E746-A750).

[0207]

In the present description, "exon 20" corresponds to a region from positions 762 to 823 in the amino acid sequence of the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6).

[0208]

In the present invention, "exon 20 mutation" refers to a point mutation, an insertion mutation, a deletion mutation, or the like in exon 20 region resulting in an amino acid mutation in the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6). Examples of the exon 20 mutation include A763insFQEA, A767insASV, S768dupSVD, V769insASV, D770insNPG, D770insSVD, and D773insNPH (Nature medicine,24,p638-646,2018). In one preferred embodiment of the present invention, the exon 20 mutation is one or more insertion mutations or point mutations selected from V769_D770insASV, D770_N771insNPG, D770_N771insSVD, H773_V774insNPH, and T790M.

[0209]

In the present description, "exon 21" corresponds to a region from positions 824 to 875 in the amino acid sequence of the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6).

[0210]

In the present invention, "exon 21 mutation" refers to a point mutation in exon 21 region resulting in an amino acid mutation in the human wild-type EGFR protein (e.g., a protein consisting of the amino acid sequence set forth in SEQ ID NO: 6). Examples of the point mutation in exon 21 include point mutations in exon 21 region, which substitute one amino acid and preferably include position mutation L858X or L861X in exon 21 region, which substitutes leucine at position 858 or leucine at position 861 with any amino acid. Examples of L858X include point mutation L858R in exon 21 region, which substitutes leucine at position 858 with arginine. Examples of L861X include point mutation L861Q in exon 21 region, which substitutes leucine at position 861 with glutamine. In one preferred embodiment of the present invention, the point mutation in exon 21 is L858R.

[0211]

In several embodiments, with regard to a mutation in a certain EGFR isoform, even when position of the mutation is different from position of an amino acid shown in SEQ ID NO: 6 due to deletion or insertion of an amino acid(s), it is understood that the mutation is the same as the mutation at a position corresponding to position of the amino acid shown in SEQ ID NO: 6. Hence, for example, the threonine at position 790 in the EGFR shown in SEQ ID NO: 6 corresponds to threonine at position 745 in EGFR consisting of the amino acid sequence set forth in SEQ ID NO: 8. For example, the term "T790M" means that the threonine at position 790 in the EGFR shown in SEQ ID NO: 6 is mutated to methionine. Since such "T790M" is at a position corresponding to the

amino acid at position 745 in EGFR consisting of the amino acid sequence set forth in SEQ ID NO: 8, "T745M" in the EGFR consisting of the amino acid sequence set forth in SEQ ID NO: 8 corresponds to "T790M" in the EGFR shown in SEQ ID NO: 6. For example, the threonine at position 790 in the EGFR shown in SEQ ID NO: 6 corresponds to threonine at position 523 in EGFR consisting of the amino acid sequence set forth in SEQ ID NO: 10. For example, the term "T790M" means that the threonine at position 790 in the EGFR shown in SEQ ID NO: 6 is mutated to methionine. Since such "T790M" is at a position corresponding to the amino acid at position 523 in EGFR consisting of the amino acid sequence set forth in SEQ ID NO: 10, "T523M" in the EGFR consisting of the amino acid sequence set forth in SEQ ID NO: 10 corresponds to "T790M" in the EGFR shown in SEQ ID NO: 6. Besides, the position of an amino acid in SEQ ID NO: 6 that corresponds to a certain amino acid in a certain EGFR isoform can be confirmed by Multiple Alignment of BLAST.

[Table B]

EGFR variant 1
Nucleotide sequence (SEQ ID NO: 5)
ATGCGACCTCCGGGACGG
CCGGGGCAGCGCTCCTGGCGCTGCTGGCTGCGCTCTGCCCGGCGAGTCGGGCTCTGGAGGAAAAGAAAGT
TTGCCAAGGCACGAGTAACAAGCTCACGCAGTTGGGCACCTTTTGAAGATCATTTTCTCAGCCTCCAGAGG
ATGTTCAATAACTGTGAGGTGGTCCTTGGGAATTTGGAAATTACCTATGTGCAGAGGAATTATGATCTTT
CCTTCTTAAAGACCATCCAGGAGGTGGCTGGTTATGTCCTCATTGCCCTCAACACAGTGGAGCGAATTCC
TTTGGAAAACCTGCAGATCATCAGAGGAAATATGTACTACGAAAATTCCTATGCCTTAGCAGTCTTATCT
AACTATGATGCAAATAAACCGGACTGAAGGAGCTGCCCATGAGAAATTTACAGGAAATCCTGCATGGCG
CCGTGCGGTTTACGCAACAACCTGCCCTGTGCAACGTGGAGAGCATCCAGTGGCGGGACATAGTCAGCAG
TGACTTTCTCAGCAACATGTGATGGACTTCCAGAACCACCTGGGCAGCTGCCAAAAGTGTGATCCAAGC
TGTCCCAATGGGAGCTGCTGGGGTGCAGGAGAGGAGAACTGCCAGAACTGACCAAAATCATCTGTGCCC
AGCAGTGCTCCGGGCGCTGCCGTGGCAAGTCCCCAGTGACTGCTGCCACAACCAAGTGTGCTGCAGGCTG
CACAGGCCCCCGGGAGAGCGACTGCCTGGTCTGCCGCAAATTCGAGACGAAGCCACGTGCAAGGACACC
TGCCCCCACTCATGCTCTACAACCCCAACACGTACCAGATGGATGTGAACCCGAGGGCAAATACAGCT
TTGGTGCCACCTGCGTGAAGAAGTGTCCCCGTAATTATGTGGTGACAGATCACGGCTCGTGCGTCCGAGC
CTGTGGGGCCGACAGCTATGAGATGGAGGAAGACGGCGTCCGCAAGTGTAAGAAGTGCAGGGGCTTGC
CGCAAAGTGTGTAACGGAATAGGTATTGGTGAATTTAAAGACTCACTCTCCATAAATGCTACGAATATTA
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CTTCACACATACTCCTCCTCTGGATCCACAGGAAGTGGATATTCTGAAAACCGTAAAGGAAATCACAGGG

TTTTGTGATTGAGGCTTGGCCTGAAAACAGGACGGACCTCCATGCCTTTGAGAACCTAGAAATCATAC
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 ACGCTCCCTCAAGGAGATAAGTGATGGAGATGTGATAATTCAGGAAACAAAATTTGTGCTATGCAAAT
 ACAATAAACTGGAAAAAACTGTTTGGGACCTCCGGTCAGAAAACAAAATTATAAGCAACAGAGGTGAAA
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 GGTGAGCCAAGGGAGTTTGTGGAGAACTCTGAGTGCATACAGTGCCACCCAGAGTGCCTGCCTCAGGCCA
 TGAACATCACCTGCACAGGACGGGGACCAGACAACGTGTATCCAGTGTGCCCACTACATTGACGGCCCCCA
 CTGCGTCAAGACCTGCCCCGCAGGAGTCATGGGAGAAAACAACACCCTGGTCTGGAAGTACGCAGACGCC
 GGCCATGTGTGCCACCTGTGCCATCCAACTGCACCTACGGATGCACTGGGCCAGGTCTTGAAGGCTGTC
 CAACGAATGGGCCTAAGATCCCGTCCATCGCCACTGGGATGGTGGGGGCCCTCCTCTTGCTGCTGGTGGT
 GGCCCTGGGGATCGGCCTCTTCATGCGAAGGCGCCACATCGTTGCGAAGCGCACGCTGCGGAGGCTGCTG
 CAGGAGAGGGAGCTTGTGGAGCCTCTTACACCCAGTGGAGAAGCTCCCAACCAAGCTCTCTTGAGGATCT
 TGAAGGAACTGAATTCAAAAAGATCAAAGTGTGGGCTCCGGTGCCTTCGGCACGGTGTATAAGGGACT
 CTGGATCCCAGAAGGTGAGAAAGTTAAAATTCCCGTCGCTATCAAGGAATTAAGAGAAGCAACATCTCCG
 AAAGCCAACAAGGAAATCCTCGATGAAGCCTACGTGATGGCCAGCGTGGACAACCCCCACGTGTGCCGCC
 TGCTGGGCATCTGCCTCACCTCCACCGTGCAGCTCATCACGCAGCTCATGCCCTTCGGCTGCCTCCTGGA
 CTATGTCCGGGAACACAAAGACAATATTGGCTCCCAGTACCTGCTCAACTGGTGTGTGCAGATCGCAAAG
 GGCATGAACTACTTGGAGGACCGTCGCTTGGTGCACCGCGACCTGGCAGCCAGGAACGTACTGGTGAAAA
 CACCGCAGCATGTCAAGATCACAGATTTTGGGCTGGCCAACTGCTGGGTGCGGAAGAGAAAGAATACCA
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 GAATCCCTGCCAGCGAGATCTCCTCCATCCTGGAGAAAGGAGAACGCCTCCCTCAGCCACCCATATGTAC
 CATCGATGTCTACATGATCATGGTCAAGTGTGGATGATAGACGCAGATAGTCGCCCAAAGTTCGGTGAG
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 GGTGGATGCCGACGAGTACCTCATCCACAGCAGGGCTTCTTCAGCAGCCCCCTCCACGTACGGACTCCC
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 CAGCATAGACGACACCTTCCTCCCAGTGCCTGAATACATAAACAGTCCGTTCCCAAAGGCCCGCTGGC
 TCTGTGCAGAATCCTGTCTATCACAATCAGCCTCTGAACCCCGCGCCCAGCAGAGACCCACACTACCAGG
 ACCCCACAGCACTGCAGTGGGCAACCCGAGTATCTCAACACTGTCCAGCCCACCTGTGTCAACAGCAC
 ATTCGACAGCCCTGCCCACTGGGCCCAGAAAGGCAGCCACCAATTAGCCTGGACAACCCTGACTACCAG
 CAGGACTTCTTTCCAAAGGAAGCCAAGCCAATGGCATCTTTAAGGGCTCCACAGCTGAAAATGCAGAAT
 ACCTAAGGGTCGCGCCACAAAGCAGTGAATTTATTGGAGCATGA

Amino acid sequence (SEQ ID NO: 6)

MRPSGTAGAALLALLAALCPASRALEEKVCQGTSNKLTLQGTTFEDHFLSLQRMFNNEVVLGNLEITYV
QRNYDLSFLKTIQEVAGYVLIALNTVERIPLNLQIIRGNMYYENSYALAVLSNYDANKTGLKELPMRNL
QEILHGAVRFSNNPALCNVESIQWRDIVSSDFLSNMSMDFQNLHLSGSCQKCDPSCPNGSCWGAGEENCQKL
TKIICAQQCSGRRCRGKSPSDCCHNQCAAGCTGPRESCLVCRKFRDEATCKDTCPPMLLYNPPTYQMDVN
PEGKYSFGATCVKKCPRNYVVTDHGSCVRACGADSYEMEEDGVRKCKKEGPCRKVCNGIGIGEFKDSLS
INATNIKHFKNCTISISGDLHILPVAFRGDSFTHTPPLDPQELDILKTVKEITGFLLIQAWPENRTDLHAF
ENLEIIRGRTKQHGGQFSLAVVSLNITSLGLRSLKEISDGDVLIISGNKNLCYANTINWKKLFGTSGQKTKI
ISNRGENSKATGQVCHALCSPEGCWGPEPRDCVSCRNVSRGRECVDKCNLLEGEPREFVENSECIQCHP
ECLPQAMNITCTGRGPDNCIQCAHYIDGPHCVKTCAPAGVMGENNTLVWKYADAGHVCHLCHPNCTYGCTG
PGLEGCTNGPKIPSIATGMVGALLLLLVVALGIGLFMRRRHIVRKRTLRLQLQERELVEPLTPSGEAPN
QALLRILKETEFKKIKVLGSGAFGTVYKGLWIPEGEKVKIPVAIKELREATSPKANKEILDEAYVMASVD
NPHVCRLLGICLTSTVQLITQLMPFGCLLDYVREHKDNIGSQYLLNWCVQIAKGMNYLEDRLVHRDLAA
RNVLVKTPQHVKITDFGLAKLLGAEKEYHAEGGKVPKWMMALESILHRIYTHQSDVWSYGVTVWELMTF
GSKPYDGIPASEISSILEKGERLPQPPICTIDVYMIMVKCWMIDADSRPKFRELIIEFSKMARDPQRYLV
IQGDERMHLPSPTDSNFYRALMDEEDMDDVDADEYLIPQQGFFSSPSTSRTPLLSSLSATSNNSTVACI
DRNGLQSCPIKEDSFLQRYSSDPTGALTEDSIDDTFLPVPEYINQSVPKRPAGSVQNPVYHNQPLNPAPS
RDPHYQDPHSTAVGNPEYLNVTQPTCVNSTFDSPAHWAKGSHQISLDNPDYQQDFFPKEAKPNGIFKGS
TAENAEYLRVAPQSSEFIGA

EGFR variant 5

Nucleotide sequence (SEQ ID NO: 7)

ATGCGACCCTCCGGGACGG

CCGGGGCAGCGCTCCTGGCGCTGCTGGCTGCGCTCTGCCGGCGAGTCGGGCTCTGGAGGAAAAGAAAGT
TTGCCAAGGCACGAGTAACAAGCTCACGCAGTTGGGCACCTTTGAAGATCATTTTCTCAGCCTCCAGAGG
ATGTTCAATAACTGTGAGGTGGTCCTTGGGAATTTGGAAATTACCTATGTGCAGAGGAATTATGATCTTT
CCTTCTTAAAGACCATCCAGGAGGTGGCTGGTTATGTCTCATTGCCCTCAACACAGTGGAGCGAATTCC
TTTGAAAACCTGCAGATCATCAGAGGAAATATGTACTACGAAAATTCCTATGCCTTAGCAGTCTTATCT
AACTATGATGCAAATAAAACCGGACTGAAGGAGCTGCCCATGAGAAATTTACAGGGCCAAAAGTGTGATC
CAAGCTGTCCCAATGGGAGCTGCTGGGGTGCAGGAGAGGAGAACTGCCAGAACTGACCAAAATCATCTG
TGCCCAGCAGTGCTCCGGGCGCTGCCGTGGCAAGTCCCCAGTGACTGCTGCCACAACAGTGTGCTGCA
GGCTGCACAGGCCCCGGGAGAGCGACTGCCTGGTCTGCCGAAATTCAGAGACGAAGCCACGTGCAAGG
ACACCTGCCCCCACTCATGCTCTACAACCCACCACGTACCAGATGGATGTGAACCCCGAGGGCAAATA
CAGCTTTGGTGCCACCTGCGTGAAGAAGTGTCCCGTAATTATGTGGTGACAGATCACGGCTCGTGCGTC
CGAGCCTGTGGGGCCGACAGCTATGAGATGGAGGAAGACGGCGTCCGCAAGTGTAAGAAGTGCGAAGGGC

CTTGCCGCAAAGTGTGTAACGGAATAGGTATTGGTGAATTTAAAGACTCACTCTCCATAAATGCTACGAA
 TATTAACACTTCAAAAACGACCTCCATCAGTGGCGATCTCCACATCCTGCCGGTGGCATTTAGGGGT
 GACTCCTTCACACATACTCCTCCTCTGGATCCACAGGAACTGGATATTCTGAAAACCGTAAAGGAAATCA
 CAGGGTTTTTGTGATTGAGGCTTGGCCTGAAAACAGGACGGACCTCCATGCCTTTGAGAACCTAGAAAT
 CATACGCGGCAGGACCAAGCAACATGGTCAGTTTTCTCTTGCAGTCGTCAGCCTGAACATAACATCCTTG
 GGATTACGCTCCCTCAAGGAGATAAGTGATGGAGATGTGATAATTTAGGAAACAAAATTTGTGCTATG
 CAAATACAATAAACTGGAAAAAACTGTTTGGGACCTCCGGTCAGAAAACCAAAATTATAAGCAACAGAGG
 TGAACACAGCTGCAAGGCCACAGGCCAGGTCTGCCATGCCTTGTGCTCCCCGAGGGCTGCTGGGGCCCG
 GAGCCAGGGACTGCGTCTCTTGGCGGAATGTCAGCCGAGGCAGGGAATGCGTGGACAAGTGCAACCTTC
 TGGAGGGTGAGCCAAGGGAGTTTGTGGAGAACTCTGAGTGCATACAGTGCCACCCAGAGTGCCTGCCTCA
 GGCCATGAACATCACCTGCACAGGACGGGGACCAGACAACCTGTATCCAGTGTGCCACTACATTGACGGC
 CCCCCTGCGTCAAGACCTGCCCCGAGGAGTCATGGGAGAAAACAACACCCCTGGTCTGGAAGTACGCAG
 ACGCCGGCCATGTGTGCCACCTGTGCCATCCAACTGCACCTACGGATGCACTGGGCCAGGTCTTGAAGG
 CTGTCCAACGAATGGGCCAAGATCCCGTCCATCGCCACTGGGATGGTGGGGGCCCTCCTCTTGCTGCTG
 GTGGTGGCCCTGGGGATCGGCCTCTTCATGCGAAGGCGCCACATCGTTGGAAGCGCACGCTGCGGAGGC
 TGCTGCAGGAGAGGGAGCTTGTGGAGCCTCTTACACCCAGTGGAGAAGCTCCCAACCAAGCTCTCTTGAG
 GATCTTGAAGGAACTGAATTCAAAAAGATCAAAGTGCTGGGCTCCGGTGCCTTCGGCACGGTGTATAAG
 GGACTCTGGATCCCAGAAGGTGAGAAAGTTAAATTCCTCGCTATCAAGGAATTAAGAGAAGCAACAT
 CTCCGAAAGCCAACAAGGAAATCCTCGATGAAGCCTACGTGATGGCCAGCGTGGACAACCCCCACGTGTG
 CCGCCTGCTGGGCATCTGCCTCACCTCCACCGTGCAGCTCATCACGCAGCTCATGCCCTTCGGCTGCCTC
 CTGGACTATGTCCGGGAACACAAAGACAATATTGGCTCCCAGTACCTGCTCAACTGGTGTGTGCAGATCG
 CAAAGGGCATGAACTACTTGGAGGACCGTGCCTTGGTGCACCGCGACCTGGCAGCCAGGAACGTACTGGT
 GAAAACACCGCAGCATGTCAAGATCACAGATTTTGGGCTGGCCAACTGCTGGGTGCGGAAGAGAAAGAA
 TACCATGCAGAAGGAGGCAAAGTGCCATCAAGTGGATGGCATTGGAATCAATTTACACAGAATCTATA
 CCCACCAGAGTGATGTCTGGAGCTACGGGGTGAAGTGTGGGAGTTGATGACCTTTGGATCCAAGCCATA
 TGACGGAATCCCTGCCAGCGAGATCTCCTCCATCCTGGAGAAAGGAGAACGCCTCCCTCAGCCACCCATA
 TGTACCATCGATGTCTACATGATCATGGTCAAGTGCTGGATGATAGACGCAGATAGTCGCCCAAAGTTCC
 GTGAGTTGATCATCGAATTTCCAAAATGGCCGAGACCCCGAGCGCTACCTTGTCTTTCAGGGGGATGA
 AAGAATGCATTTGCCAAGTCCTACAGACTCCAACCTTCTACCGTGCCTGATGGATGAAGAAGACATGGAC
 GACGTGGTGGATGCCGACGAGTACCTCATCCACAGCAGGGCTTCTTCAGCAGCCCTCCACGTACGGA
 CTCCCCCTCCTGAGCTCTCTGAGTGCAACCAGCAACAATTCACCGTGGCTTGCATTGATAGAAATGGGCT
 GCAAAGCTGTCCCATCAAGGAAGACAGCTTCTTGCAGCGATACAGCTCAGACCCACAGGCGCCTTGACT
 GAGGACAGCATAGACGACACCTTCCTCCAGTGCCTGGTGGTGGCTTGTCTGGAACAGTCCTGCTCCT
 CAACCTCCTCGACCCACTCAGCAGCAGCCAGTCTCCAGTGTCCAAGCCAGGTGCTCCCTCCAGCATCTCC
 AGAGGGGGAAACAGTGGCAGATTTGCAGACACAGTGA

Amino acid sequence (SEQ ID NO: 8)

MRPSGTAGAALLALLAALCPASRALEEKVCQGTSNKLTQLGTFEDHFLSLQRMFNNCEVVLGNLEITYV
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QGQKCDPSCPNNGSCWGAGEENCQKLTKIICAQQCSGRGRGKSPSDCCHNQCAAGCTGPRESDCLVCRKFR
DEATCKDTCPPMLYNPTTYQMDVNPEGKYSFGATCVKKCPRNYVVDHGSVCVRACGADSYEMEEDGVRK
CKKCEGPCRKVCNGIGIGIEFKDSLSINATNIKHFKNCTSSISGDLHILPVAFRGDSFTHTPPLDPQELDIL
KTVKEITGFLLIQAWPENRTDLHAFENLEIIRGRTKQHGFSLAVVSLNITSLGLRSLKEISDGDVVISG
NKNLCYANTINWKKLFGTSGQKTKIISNRGENSCKATGQVCHALCSPEGCWGPEPRDCVSCRNVSRGREG
VDKCNLLEGEPRFVENSECIQCHPECLPQAMNITCTGRGPDNCIQCAHYIDGPHCVKTCPAGVMGENNT
LVWKYADAGHVCHLCHPNCTYGCTGPGLEGCPNGPKIPSIATGMVGAALLLLLVVALGIGLFMRRRHIVR
KRTLRLLLQERELVEPLTPSGEAPNQALLRILKETEFKKIKVLGSGAFGTVYKGLWIPEGEKVKIPVAIK
ELREATSPKANKEILDEAYVMASVDNPHVCRLLGICLTSTVQLITQLMPFGCLLDYVREHKDNIGSQYLL
NWCQVIAKGMNYLEDRLVHRDLAARNVLVKTPQHVKITDFGLAKLLGAEEKEYHAEGGKVPIKWMALLES
ILHRIYTHQSDVWSYGVTVWELMTFGSKPYDGIPASEISSILEKGERLPQPPICTIDVYMIMVKCWMIDA
DSRPKFRELIIIEFSKMARDPQRYLVIQGDERMHLPSPTDSNFYRALMDEEDMDDVVDADLEYLIPQQGFFS
SPSTSRTPLSSLATSNNSTVACIDRNLQSCPIKEDSFLQRYSSDPTGALTEDSIDDTFLPVPGEWL
WKQSCSSTSTHSAAASLQCPSQVLPPASPEGETVADLQTQ

EGFR VIII

Nucleotide sequence (SEQ ID NO: 9)

ATGCGACCTCCGGGACGG
CCGGGGCAGCGCTCCTGGCGCTGCTGGCTGCGCTCTGCCCGGCGAGTCGGGCTCTGGAGGAAAAGAAAGG
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GACGGCGTCCGCAAGTGTAAAGAGTGCAGAGGGCCTTGCCGCAAAGTGTGTAACGGAATAGGTATTGGTG
AATTTAAAGACTCACTCTCCATAAATGCTACGAATATTAAACACTTCAAAAAGTGCACCTCCATCAGTGG
CGATCTCCACATCCTGCCGGTGGCATTTAGGGGTGACTCCTTCACACATACTCCTCCTCTGGATCCACAG
GAACTGGATATTCTGAAAACCGTAAAGGAAATCACAGGGTTTTTGTCTGATTGAGGCTTGGCTGAAAACA
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TCTTGAGTCGTCAGCCTGAACATAACATCCTTGGGATTACGCTCCCTCAAGGAGATAAGTGATGGAGAT
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CCGGTCAGAAAACCAAAATTATAAGCAACAGAGGTGAAACAGCTGCAAGGCCACAGGCCAGGTCTGCCA
TGCCTTGTGCTCCCCGAGGGCTGCTGGGGCCCGAGGCCAGGGACTGCGTCTCTTGCCGGAATGTCAGC
CGAGGCAGGGAATGCGTGGACAAGTGCAACCTTCTGGAGGGTGAGCCAAGGGAGTTTGTGGAGAACTCTG
AGTGCATACAGTGCCACCCAGAGTGCCTGCCTCAGGCCATGAACATCACCTGCACAGGACGGGGACCAGA
CAACTGTATCCAGTGTGCCCACTACATTGACGGCCCCCACTGCGTCAAGACCTGCCCGGCAGGAGTCATG

GGAGAAAACAACACCCTGGTCTGGAAGTACGCAGACGCCGGCCATGTGTGCCACCTGTGCCATCCAAACT
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CACTGGGATGGTGGGGGCCCTCCTCTTGCTGCTGGTGGTGGCCCTGGGGATCGGCCTCTTCATGCGAAGG
CGCCACATCGTTTCGGAAGCGCACGCTGCGGAGGCTGCTGCAGGAGAGGGAGCTTGTGGAGCCTCTTACAC
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CCCGTCGCTATCAAGGAATTAAGAGAAGCAACATCTCCGAAAGCCAACAAGGAAATCCTCGATGAAGCCT
ACGTGATGGCCAGCGTGGACAACCCCCACGTGTGCCGCCTGCTGGGCATCTGCCTCACCTCCACCGTGCA
GCTCATCACGCAGCTCATGCCCTTCGGCTGCCTCCTGGACTATGTCCGGGAACACAAAGACAATATTGGC
TCCAGTACCTGCTCAACTGGTGTGTGCAGATCGCAAAGGGCATGAACTACTTGGAGGACCGTCGCTTGG
TGCACCGCGACCTGGCAGCCAGGAACGTACTGGTGAAAACACCGCAGCATGTCAAGATCACAGATTTTGG
GCTGGCCAAACTGCTGGGTGCGGAAGAGAAAGAATACCATGCAGAAGGAGGCAAAGTGCCTATCAAGTGG
ATGGCATTGGAATCAATTTTACACAGAATCTATACCCACCAGAGTGATGTCTGGAGCTACGGGGTGACTG
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GGAGAAAGGAGAACGCCTCCCTCAGCCACCCATATGTACCATCGATGTCTACATGATCATGGTCAAGTGC
TGGATGATAGACGCAGATAGTCGCCCCAAAGTTCCGTGAGTTGATCATCGAATTCTCCAAATGGCCCCGAG
ACCCCCAGCGCTACCTTGTCAATCAGGGGGATGAAAGAATGCATTTGCCAAGTCTACAGACTCCAACTT
CTACCGTGCCCTGATGGATGAAGAAGACATGGACGACGTGGTGGATGCCGACGAGTACCTCATCCACAG
CAGGGCTTCTTCAGCAGCCCCCTCCACGTCACGGACTCCCCCTCCTGAGCTCTCTGAGTGCAACCAGCAACA
ATTCCACCGTGGCTTGCATTGATAGAAATGGGCTGCAAAGCTGTCCCATCAAGGAAGACAGCTTCTTGCA
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GAATACATAAACCAGTCCGTTCCTCCAAAGGCCCGCTGGCTCTGTGCAGAATCCTGTCTATCACAATCAGC
CTCTGAACCCCGCGCCCAGCAGAGACCCACACTACCAGGACCCCCACAGCACTGCAGTGGGCAACCCCGA
GTATCTCAACACTGTCCAGCCCACCTGTGTCAACAGCACATTGACAGCCCTGCCACTGGGCCCAGAAA
GGCAGCCACCAAATTAGCCTGGACAACCCTGACTACCAGCAGGACTTCTTTCCCAAGGAAGCCAAGCCAA
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TATTGGAGCATGA

Amino acid sequence (SEQ ID NO: 10)

MRPSGTAGAALLALLAALCPASRALEEKKNYVVDHGSVCVRACGADSYEMEEDGVRKCKKCEGPCRKVC
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QAWPENRTDLHAFENLEIIRGRTKQHGGQFSLAVVSLNITSLGLRSLKEISDGDVLIISGNKNLCYANTINW
KKLFGTSGQKTKIISNRGENSCKATGQVCHALCSPEGCWGPEPRDCVSCRNVSRGRECVDKCNLLEGEPR
EFVENSECIQCHPECLPQAMNITCTGRGPDNCIQCAHYIDGPHCVKTCPAGVMGENNTLVWKYADAGHVC
HLCHPNCTYGCTGPGLEGCPNPKIPSIATGMVGALLLLLVALGIGLFMRRRHIVRKRTLRLRLQERE
LVEPLTPSGEAPNQALLRILKETEFKKIKVLGSGAFGTVYKGLWIPEGEKVKIPVAIKELREATSPKANK

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EILDEAYVMASVDNPHVCRLLGICLTSTVQLITQLMPFGCLLDYVREHKDNIGSQYLLNWCVQIAKGMNY
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WSYGVTVWELMTFGSKPYDGIPASEISSILEKGERLPQPPICTIDVYMIMVKCWMIDADSRPKFRELIIE
FSKMARDPQRYLVIQGDERMHLPSPTDSNFYRALMDEEDMDDVVDADAYLIPQQGFFSSPSTSRTPLLSS
LSATSNNSTVACIDRNLQSCPIKEDSFLQRYSSDPTGALTEDSIDDTFLPVPEYINQSVPKRPAGSVQN
PVYHNQPLNPAPSRDPHYQDPHSTAVGNPEYLNVTQPTCVNSTFDSPAHWAKGSHQISLDNPDYQQDFF
PKEAKPNGIFKGSTAENAEYLRVAPQSSEFIGA

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[0212]

In the present invention, "HER2-positive tumor" is tumor in which the HER2 protein or the HER2 gene is detected. The HER2 protein and the HER2 gene also include mutant HER2 protein and mutant HER2 gene having a point mutation, an insertion mutation, or a deletion mutation, etc.

[0213]

Examples of the method for detecting the HER2 protein include usual detection methods commonly used, such as ELISA, Western blotting, and immunostaining using an antibody specifically binding to the HER2 protein. The antibody specifically binding to the HER2 protein may be a commercially available product or may be prepared by a usual method commonly used.

[0214]

Examples of the method for detecting the HER2 gene include usual detection methods commonly used, such as Northern blotting, Southern blotting, RT-PCR, real-time PCR, digital PCR, DNA microarrays, *in situ* hybridization, and sequence analysis.

[0215]

In the present invention, "EGFR-positive tumor" is tumor in which the EGFR protein or the EGFR gene is detected. The EGFR protein and the EGFR gene also include mutant EGFR protein and mutant EGFR gene having a point mutation, an insertion mutation, or a deletion mutation, etc.

[0216]

Examples of the method for detecting the EGFR protein include usual detection methods commonly used, such as ELISA, Western blotting, and immunostaining using an antibody specifically binding to the EGFR protein. The antibody specifically binding to the EGFR protein may be a commercially available product or may be prepared by a usual method commonly used.

[0217]

Examples of the method for detecting the EGFR gene include usual detection

methods commonly used, such as Northern blotting, Southern blotting, RT-PCR, real-time PCR, digital PCR, DNA microarrays, *in situ* hybridization, and sequence analysis. Another example thereof includes a detection method using cobas EGFR mutation detection kit (Roche Diagnostics K.K.), which is a commercially available EGFR gene mutation detection kit.

[0218]

In the present description, the term "effective amount" used regarding the pyrimidine compound and the other antitumor agent of the present invention means the amount of the pyrimidine compound and the other antitumor agent of the present invention that induces the biological or medical response of a subject, such as, for example, reduction or inhibition of enzyme or protein activity; or ameliorates symptoms, alleviates conditions, and retards or delays the progression of disease; or prevents disease; etc. (therapeutically effective amount).

In the present description, the term "subject" includes mammals and non-mammals. Examples of the mammal may include, but are not limited to, a human, a chimpanzee, an ape, a monkey, a bovine, a horse, sheep, a goat, a swine, a rabbit, a dog, a cat, a rat, a mouse, a Guinea pig, a hedgehog, a kangaroo, a mole, a wild pig, a bear, a tiger, and a lion. Examples of the non-mammal may include, but are not limited to, birds, fish, and reptiles. In one embodiment, the subject is a human, and may be a human who has been diagnosed to need the treatment for the symptoms, conditions or disease disclosed in the present description.

[0219]

Upon the use of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent as a medicament, a pharmaceutically acceptable carrier is mixed into it, as necessary, and various types of dosage forms can be adopted depending on the preventive or therapeutic purpose. Examples of the dosage form may include all of an oral agent, an injection, a suppository, an ointment, and a patch. Preferably, an oral agent is adopted. These dosage forms can be produced by commonly used production methods that are known to skilled persons. The pyrimidine compound of the present invention or the salt thereof and the other antitumor agent may be administered in the same dosage forms or may be administered in different dosage forms.

[0220]

The dosing schedule of the pyrimidine compound of the present invention or a salt thereof and other antitumor agent is appropriately selected within a range in which each active ingredient exerts an antitumor effect. These active ingredients are administered concurrently or separately at an interval. For separate administration,

either of them may be administered first.

[0221]

The pyrimidine compound of the present invention or a salt thereof and other antitumor agent may be produced in a plurality of divided dosage forms of the respective active ingredients or may be produced together in one dosage form, on the basis of the dosage form or dosing schedule of each active ingredient. Also, the respective preparations may be produced and sold together in one package suitable for combined use or may be produced and sold in separate packages.

In one embodiment, the pyrimidine compound of the present invention or the salt thereof and the other antitumor agent are in the same preparation. Such a preparation may be, for example, a pharmaceutical composition comprising the pyrimidine compound of the present invention or the salt thereof, the other antitumor agent, and a pharmaceutically acceptable carrier.

In one embodiment, the pyrimidine compound of the present invention or the salt thereof and the other antitumor agent are in individual preparations. Such preparations may be, for example, a combination of a pharmaceutical composition comprising the pyrimidine compound of the present invention or the salt thereof and a pharmaceutically acceptable carrier, and a pharmaceutical composition comprising the other antitumor agent and a pharmaceutically acceptable carrier.

One embodiment of the present invention provides a kit preparation comprising the antitumor agent or the pharmaceutical combination mentioned above and an instruction stating that the pyrimidine compound or the salt thereof and the other antitumor agent are combined-administered.

[0222]

As pharmaceutically acceptable carriers, various types of organic or inorganic carrier substances, which are commonly used as preparation materials, are used. When the compound of the present invention is processed into a solid preparation, examples of the pharmaceutically acceptable carrier mixed into the compound of the present invention may include an excipient, a binder, a disintegrator, a lubricant, a coating agent, and a coloring agent. When the compound of the present invention is processed into a liquid preparation, examples of the pharmaceutically acceptable carrier mixed into the compound of the present invention may include a solvent, a solubilizer, a suspending agent, a tonicity agent, a buffer, and a soothing agent. In addition, preparation additives such as an antiseptic, an antioxidant, a sweetener, and a stabilizer can also be used, as necessary.

[0223]

In the case of preparing a solid preparation for oral administration, an excipient, and as necessary, a binder, a disintegrator, a lubricant, a coloring agent, a corrigent, etc. are added to the pyrimidine compound of the present invention, and thereafter, a tablet, a coated tablet, a granule, a powder agent, a capsule, etc. can be produced according to ordinary methods.

In the case of preparing an injection, a pH adjuster, a buffer, a stabilizer, a tonicity agent, a local anesthetic, etc. are added to the pyrimidine compound of the present invention, and thereafter, subcutaneous, intramuscular, and intravenous injections can be produced according to ordinary methods.

[0224]

The amount of the pyrimidine compound or the salt thereof of the present invention to be mixed into the above-described each dosage unit form depends on the symptoms of a subject to whom the present compound should be applied, the dosage form and the like, and thus, the amount of the compound of the present invention is not constant. In general, it is preferable that the applied dose is set to be 0.05 to 1000 mg per dosage unit form as the pyrimidine compound in the case of an oral agent, it is set to be 0.01 to 500 mg per dosage unit form as the pyrimidine compound in the case of an injection, and it is set to be 1 to 1000 mg per dosage unit form as the pyrimidine compound in the case of a suppository.

The amount of the other antitumor agent to be mixed into the above-described each dosage unit form depends on the symptoms of a subject to whom the other antitumor agent should be applied, the dosage form and the like, and thus, the amount of the other antitumor agent is not constant. In general, it is preferable that the applied dose is set to be 0.05 to 1000 mg per dosage unit form in the case of an oral agent, it is set to be 0.01 to 500 mg per dosage unit form in the case of an injection, and it is set to be 1 to 1000 mg per dosage unit form in the case of a suppository.

The daily dose of a drug having the above-described dosage form is different depending on the symptoms, body weight, age, sex and the like of a subject, and thus, it cannot be generally determined. The pyrimidine compound of the present invention may be administered to an adult (body weight: 50 kg) at a daily dose of generally 0.05 to 5000 mg, and preferably 0.1 to 1000 mg. Also the amount of the other antitumor agent is different depending on the symptoms, body weight, age, sex and the like of a subject, and thus, it cannot be generally determined. For example, the other antitumor agent may be administered to an adult (body weight: 50 kg) at a daily dose of generally 0.05 to 5000 mg, and preferably 0.1 to 1000 mg.

[0225]

In the present invention, the daily dose of the pyrimidine compound or the salt thereof and the other antitumor agent may be a dose that is determined by clinical trials or the like and brings about the maximum therapeutic effect within a range in which they can be safely used without developing serious side effects. Specific examples thereof include doses that are approved, recommended, and/or advised by public agencies or institutions such as the Pharmaceuticals and Medical Devices Agency (PMDA), the Food and Drug Administration (FDA), and the European Medicines Agency (EMA) and described in package inserts, interview forms, and/or treatment guidelines. Preferable is a dose approved by any public institution of PMDA, FDA and EMA.

[0226]

The malignant tumor that is the target of the present invention is not particularly limited. Examples of the tumor may include brain tumor, head and neck cancer, digestive cancer (esophageal cancer, stomach cancer, duodenal cancer, liver cancer, biliary tract cancer (gallbladder and/or bile duct cancer, etc.), pancreatic cancer, colorectal cancer (colon cancer, rectal cancer, etc.), etc.), lung cancer (non-small cell lung cancer, small cell lung cancer, mesothelioma, etc.), breast cancer, genital cancer (ovarian cancer, uterine cancer (cervical cancer, endometrial cancer, etc.), etc.), urinary organ cancer (kidney cancer, bladder cancer, prostate cancer, testicular tumor, etc.), hematopoietic tumor (leukemia, malignant lymphoma, multiple myeloma, etc.), bone and/or soft tissue tumor, and skin cancer. Among these, preferable is brain tumor, lung cancer, breast cancer, stomach cancer, colorectal cancer, bladder cancer, biliary tract cancer or uterine cancer, and more preferable is brain tumor, lung cancer, breast cancer, stomach cancer, colorectal cancer, bladder cancer, or biliary tract cancer.

[0227]

In one embodiment, the tumor that is the target of the present invention is malignant tumor having HER2 overexpression, HER2 gene amplification, or HER2 mutation. Examples of the malignant tumor may include brain tumor, head and neck cancer, digestive cancer (esophageal cancer, stomach cancer, duodenal cancer, liver cancer, biliary tract cancer (gallbladder and/or bile duct cancer, etc.), pancreatic cancer, colorectal cancer (colon cancer, rectal cancer, etc.), etc.), lung cancer (non-small cell lung cancer, small cell lung cancer, mesothelioma, etc.), breast cancer, genital cancer (ovarian cancer, uterine cancer (cervical cancer, endometrial cancer, etc.), etc.), urinary organ cancer (kidney cancer, bladder cancer, prostate cancer, testicular tumor, etc.), hematopoietic tumor (leukemia, malignant lymphoma, multiple myeloma, etc.), bone and/or soft tissue tumor, and skin cancer. Among these, preferable is brain tumor, lung cancer, breast cancer, stomach cancer, colorectal cancer, bladder cancer, biliary tract

cancer or uterine cancer, and more preferable is brain tumor, lung cancer, breast cancer, stomach cancer, bladder cancer, or biliary tract cancer.

[0228]

In one embodiment, the tumor that is the target of the present invention is HER2-positive tumor. Examples of the tumor may include brain tumor, head and neck cancer, digestive cancer (esophageal cancer, stomach cancer, duodenal cancer, liver cancer, biliary tract cancer (gallbladder and/or bile duct cancer, etc.), pancreatic cancer, colorectal cancer (colon cancer, rectal cancer, etc.), etc.), lung cancer (non-small cell lung cancer, small cell lung cancer, mesothelioma, etc.), breast cancer, genital cancer (ovarian cancer, uterine cancer (cervical cancer, endometrial cancer, etc.), etc.), urinary organ cancer (kidney cancer, bladder cancer, prostate cancer, testicular tumor, etc.), hematopoietic tumor (leukemia, malignant lymphoma, multiple myeloma, etc.), bone and/or soft tissue tumor, and skin cancer. Among these, preferable is brain tumor, lung cancer, breast cancer, stomach cancer, colorectal cancer, bladder cancer, biliary tract cancer or uterine cancer, and more preferable is brain tumor, lung cancer, breast cancer, stomach cancer, bladder cancer, or biliary tract cancer.

[0229]

In one embodiment, the tumor that is the target of the present invention is malignant tumor having EGFR overexpression, EGFR gene amplification, or an EGFR mutation. Examples of the malignant tumor may include brain tumor, head and neck cancer, digestive cancer (esophageal cancer, stomach cancer, duodenal cancer, liver cancer, biliary tract cancer (gallbladder and/or bile duct cancer, etc.), pancreatic cancer, colorectal cancer (colon cancer, rectal cancer, etc.), etc.), lung cancer (non-small cell lung cancer, small cell lung cancer, mesothelioma, etc.), breast cancer, genital cancer (ovarian cancer, uterine cancer (cervical cancer, endometrial cancer, etc.), etc.), urinary organ cancer (kidney cancer, bladder cancer, prostate cancer, testicular tumor, etc.), hematopoietic tumor (leukemia, malignant lymphoma, multiple myeloma, etc.), bone and/or soft tissue tumor, and skin cancer. Among these, preferable is brain tumor, head and neck cancer, lung cancer, breast cancer, stomach cancer, colorectal cancer, bladder cancer, biliary tract cancer or uterine cancer, and more preferable is brain tumor, lung cancer, breast cancer, or colorectal cancer.

[0230]

In one embodiment, the tumor that is the target of the present invention is EGFR-positive tumor. Examples of the tumor may include brain tumor, head and neck cancer, digestive cancer (esophageal cancer, stomach cancer, duodenal cancer, liver cancer, biliary tract cancer (gallbladder and/or bile duct cancer, etc.), pancreatic cancer, colorectal

cancer (colon cancer, rectal cancer, etc.), etc.), lung cancer (non-small cell lung cancer, small cell lung cancer, mesothelioma, etc.), breast cancer, genital cancer (ovarian cancer, uterine cancer (cervical cancer, endometrial cancer, etc.), etc.), urinary organ cancer (kidney cancer, bladder cancer, prostate cancer, testicular tumor, etc.), hematopoietic tumor (leukemia, malignant lymphoma, multiple myeloma, etc.), bone and/or soft tissue tumor, and skin cancer. Among these, preferable is brain tumor, head and neck cancer, lung cancer, breast cancer, stomach cancer, colorectal cancer, bladder cancer, biliary tract cancer or uterine cancer, and more preferable is brain tumor, lung cancer, breast cancer, or colorectal cancer.

[0231]

In one embodiment, the tumor is a brain tumor. The pyrimidine compound of the present invention may be useful for the treatment of the symptoms of brain that is required to pass through the blood-brain barrier. The pyrimidine compound of one embodiment has favorable permeability through the blood-brain barrier for the delivery thereof into the brain, namely, excellent brain penetration properties. As an indicator of the penetration properties of the compound into the brain, the concentration of the compound in the brain or a K_p value (brain-to-plasma drug concentration ratio) is applied.

The brain tumor to be treated in the present invention includes metastatic brain tumor and primary brain tumor.

Examples of the brain tumor may include, but are not particularly limited to, metastatic brain tumor (e.g., brain metastasis of lung cancer, breast cancer, stomach cancer, colorectal cancer, bladder cancer, biliary tract cancer, uterine cancer, etc. (preferably, lung cancer, breast cancer, or stomach cancer)), pilocytic astrocytoma, diffuse astrocytoma, oligodendroma and/or oligodendroastrocytoma, anaplastic astrocytoma and/or anaplastic oligodendroglioma, anaplastic oligodendroastrocytoma, glioblastoma, ependymoma, anaplastic ependymoma, ganglioglioma, central neurocytoma, medulloblastoma, germinoma, central nervous system malignant lymphoma, meningioma, neurilemmoma, GH secreting pituitary adenoma, PRL-secreting pituitary adenoma, ACTH-secreting pituitary adenoma, nonfunctional pituitary adenoma, craniopharyngioma, chordoma, hemangioblastoma, and epidermoid tumor.

EXAMPLES

[0232]

Hereinafter, the present invention will be described in detail in the following examples. However, these examples are not intended to limit the scope of the present invention.

In the present description, "room temperature" generally means a temperature that is from approximately 10°C to approximately 35°C. In addition, in the following Examples regarding compounds, "%" indicates weight percent, unless otherwise specified.

Various types of reagents used in the Examples were commercially available products, unless otherwise specified. Silica gel chromatography was carried out using Biotage SNAP Cartridge Ultra, manufactured by Biotage Japan Ltd. Basic silica gel chromatography was carried out using Biotage SNAP Cartridge Isolute Flash-NH₂, manufactured by Biotage Japan Ltd.

Preparative thin-layer chromatography was carried out using Kieselgel TM60F254, Art. 5744, manufactured by Merck, or NH₂ Silica Gel 60F254 Plate-Wako, manufactured by FUJIFILM Wako Pure Chemical Cooperation.

¹H-NMR was measured using tetramethylsilane as a reference material, and employing AL400 (400 MHz) manufactured by JEOL, Mercury (400 MHz) manufactured by Varian, or Inova (400 MHz) manufactured by Varian. Moreover, mass spectrum was measured using Micromass ZQ or SQD manufactured by Waters, according to electrospray ionization (ESI) or atmospheric pressure chemical ionization (APCI). Microwave reaction was carried out using Initiator manufactured by Biotage Japan Ltd.

Abbreviations have the following meanings.

s: Singlet

d: Doublet

t: Triplet

q: Quartet

dd: Double doublet

dt: Double triplet

td: Triple doublet

tt: Triple triplet

ddd: Double double doublet

ddt: Double double triplet

dtd: Double triple doublet

tdd: Triple double doublet

m: Multiplet

br: Broad

ATP: Adenosine triphosphate

DMSO-d₆: Deuterated dimethyl sulfoxide

CDCl₃: Deuterated chloroform

EDTA: Ethylenediaminetetraacetic acid

THF: Tetrahydrofuran

DMF: N,N-dimethylformamide

DMSO: Dimethyl sulfoxide

NMP: N-methyl pyrrolidone

HATU: O-(7-azabenzotriazol-1-yl)-N,N,N',N'-tetramethyluronium hexafluorophosphate

HPMC: Hypromellose

PdCl₂(PPh₃)₂: Dichlorobis(triphenylphosphine)palladium(II)

po: Oral administration

iv: Intravenous administration

T-mab: Trastuzumab

P-mab: Pertuzumab

[0233]

Reference Example 1

Reference Example 1(1)

tert-Butyl (2S,4R)-4-(4-amino-5-iodo-7H-pyrrolo[2,3-d]pyrimidin-7-yl)-2-methylpyrrolidine-1-carboxylate

tert-Butyl (2S,4S)-4-hydroxy-2-methylpyrrolidine-1-carboxylate (19.0 g) and 4-chloro-5-iodo-7H-pyrrolo[2,3-d]pyrimidine (13.1 g) were dissolved in THF (190 mL), and the obtained solution was then cooled to 0°C. Thereafter, triphenylphosphine (37.2 g) and diisopropyl azodicarboxylate (28.1 mL) were added to the reaction solution, and the temperature of the mixture was then increased to room temperature, followed by stirring for 1 hour. Thereafter, the reaction mixture was concentrated under reduced pressure, and the obtained residue was then purified by silica gel chromatography (hexane : ethyl acetate) to obtain the corresponding coupling body. The obtained compound was used in the subsequent reaction without being further purified.

The obtained coupling body, THF (114 mL) and ammonia water (114 mL) were added into a pressure resistant tube, and the obtained mixture was then stirred at 100°C for 14 hours. Thereafter, the reaction mixture was cooled to room temperature, and was then poured into water (285 mL). The thus obtained mixture was stirred at room temperature for 5 hours. Thereafter, the precipitated solid was collected by filtration, was then washed with water, and was then dried to obtain a product of interest (34.5 g).

¹HNMR (CDCl₃)δ: 8.27(s,1H) 7.15(s,1H) 5.55-5.73(m,2H) 5.12-5.25(m,1H) 3.86-4.18(m,2H) 3.43-3.57(m,1H) 2.59-2.69(m,1H) 1.92-2.03(m,1H) 1.48(s,9H) 1.30-1.40(m,3H)

ESI-MS m/z 444 (MH⁺)

[0234]

Reference Example 1(2)

4-Amino-7-((3R,5S)-1-(tert-butoxycarbonyl)-5-methylpyrrolidin-3-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxylic acid

The compound of Reference Example 1(1) (28.0 g), 10% palladium carbon catalyst (720 mg), NMP (84 mL), methanol (26 mL), and triethylamine (17.6 mL) were added into a pressure resistant tube, followed by carbon monoxide substitution, and the obtained mixture was stirred at 100°C for 2 hours. Thereafter, the reaction mixture was cooled to room temperature, a 2 M sodium hydroxide aqueous solution (79 mL) was then added thereto, and the obtained mixture was then stirred at 80°C for 2 hours. Thereafter, the reaction mixture was cooled to room temperature, was then filtrated through Celite, and was then washed with methanol. Subsequently, methanol in the filtrate was concentrated under reduced pressure. Water was further added, and the water layer was then washed with tert-butyl methyl ether. A 1 M potassium hydrogen sulfate aqueous solution was added to the water layer to adjust the pH to approximately 3. The precipitated solid was collected by filtration, was then washed with water, and was then dried to obtain a product of interest (23.4 g).

¹HNMR (400MHz, DMSO-d₆)δ: 8.14 (s, 1H) 8.08 (s, 1H) 5.16-4.93(m,1H) 4.07-3.79(m,2H) 3.61-3.45(m,1H) 2.53(m,1H) 2.33-2.02(m,1H) 1.42(s,9H) 1.29(d,J = 6.1Hz,3H) ESI-MS m/z 362 (MH⁺)

[0235]

Examples

Example 1(1)

tert-Butyl-4-amino-6-bromo-7-((3R,5S)-1-(tert-butoxycarbonyl)-5-methylpyrrolidin-3-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxylate

Under a nitrogen atmosphere, the compound of Reference Example 1(2) (15.0 g) was dissolved in chloroform (150 mL), and 2-tert-butyl-1,3-diisopropylisourea (25 mL) was then added to the above obtained solution. The temperature of the obtained mixture was increased to 60°C, and the mixture was then stirred for 2 hours. Thereafter, 2-tert-butyl-1,3-diisopropylisourea (25 mL) was further added to the reaction mixture, and the thus obtained mixture was then stirred for 2 hours. Thereafter, the reaction mixture was cooled to room temperature, and was then concentrated under reduced pressure. To the obtained residue, tert-butyl methyl ether was added, and the precipitated solid was collected by filtration and was then washed with tert-butyl methyl ether. The filtrate was concentrated under reduced pressure, and tert-butyl methyl ether was then added to the obtained residue. The precipitated solid was collected by filtration,

and was then washed with tert-butyl methyl ether. The obtained residue was purified by silica gel chromatography (hexane : ethyl acetate) to obtain a tert-butyl ester form. The obtained compound was used in the subsequent halogenation reaction without being further purified.

The obtained tert-butyl ester form was dissolved in chloroform (140 mL), and N-bromosuccinimide (11.8 g) was then added to the above obtained solution. The obtained mixture was stirred at room temperature for 24 hours. Thereafter, to the reaction mixture, chloroform and 10% sodium bisulfite aqueous solution were successively added, and the obtained mixture was then extracted with chloroform. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : ethyl acetate) to obtain a product of interest (13.8 g).

¹HNMR (CDCl₃)δ: 8.02 (s, 1H) 5.74-5.13(m,2H) 4.07-3.64(m,2H) 2.43-2.29(m,1H) 2.07-1.97(m,1H) 1.63(s,9H) 1.48(m,12H)

ESI-MS m/z 496,498 (MH⁺)

[0236]

Example 1(2)

tert-Butyl-7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-bromo-7H-pyrrolo[2,3-d]pyrimidine-5-carboxylate

The compound of Example 1(1) (11.4 g) was dissolved in THF (57 mL), and the obtained solution was then cooled to 0°C. Thereafter, 4 M hydrogen chloride in 1,4-dioxane solution (114 mL) was added to the mixture, and the thus obtained mixture was then stirred at 0°C for 10 hours. Subsequently, to the reaction mixture, a 5 M sodium hydroxide aqueous solution (92 mL), acetonitrile (57 mL), diisopropylethylamine (20 mL), and acryloyl chloride (2.0 mL) were added, and the obtained mixture was then stirred for 30 minutes. Thereafter, the reaction mixture was extracted with ethyl acetate, and the gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain a product of interest (7.72 g).

¹HNMR (CDCl₃)δ: 8.26-8.16(m,1H) 6.62-6.30(m,2H) 5.81-5.64(m,1H) 5.33-5.14(m,1H) 4.81-3.75(m,3H) 3.07-2.86(m,1H) 2.67-2.33(m,1H) 1.69-1.61(m,9H) 1.60-1.51(m,3H)

ESI-MS m/z 450,452 (MH⁺)

[0237]

Example 1(3)

tert-Butyl-7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxylate

1.0 M Propyne in DMF solution (85.7 mL) was added to the compound of Example 1(2) (7.72 g), acetonitrile (154 mL), triethylamine (7.2 mL), PdCl₂(PPh₃)₂ (1.2 g), and copper(I) iodide (330 mg), followed by nitrogen substitution. Thereafter, the mixture was stirred at 70°C for 4 hours. Thereafter, the reaction mixture was cooled to room temperature, and ethyl acetate and a saturated sodium hydrogen carbonate aqueous solution were added to the mixture. Thereafter, the obtained mixture was extracted with ethyl acetate, and the gathered organic layer was washed with water, and then with saturated saline. The resultant was dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain a product of interest (4.06 g).

¹HNMR (CDCl₃)δ: 8.29-8.17(m,1H) 6.63-6.30(m,2H) 5.81-5.63(m,1H) 5.42-5.15(m,1H) 4.66-3.81(m,3H) 3.01-2.82(m,1H) 2.65-2.32(m,1H) 2.92-2.13(m,3H) 1.65-1.59(m,9H) 1.57-1.49(m,3H)

ESI-MS m/z 410 (MH⁺)

[0238]

Example 1(4)

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-carboxylic acid

The compound of Example 1(3) (1.52 g) was dissolved in chloroform (5 mL), and trifluoroacetic acid (5 mL) was then added to the above obtained solution. The mixture was stirred at room temperature for 2 hours, and the reaction mixture was then concentrated under reduced pressure. To the residue, chloroform was added, and the obtained mixture was concentrated under reduced pressure again. The residue was dried under reduced pressure to obtain a product of interest (1.25 g).

ESI-MS m/z 354 (MH⁺)

[0239]

Example 1(5)

7-(R)-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-(3,5-difluorophenyl)ethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

To the compound of Example 1(4) (100 mg) in DMF (1.0 mL) solution, (R)-1-(3,5-difluorophenyl)ethan-1-amine (89.0 mg), diisopropylethylamine (0.25 mL), and HATU (215 mg) were added, and the obtained mixture was then stirred at room temperature for 2 hours. Thereafter, to the reaction mixture, a saturated sodium hydrogen carbonate aqueous solution was added, and the obtained mixture was then

extracted with ethyl acetate. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain the title compound (60 mg).

¹HNMR (DMSO-d₆)δ: 8.51(d, *J* = 7.3Hz, 1H) 8.16 (s, 1H) 7.25-7.07(m, 3H) 6.74-6.47(m, 1H) 6.25-6.08(m, 1H) 5.78-5.58(m, 1H) 5.41-5.21(m, 1H) 5.21-5.06(m, 1H) 4.45-4.29(m, 1H) 4.24-3.91(m, 2H) 2.78-2.58(m, 1H) 2.52-2.41(m, 1H) 2.23(s, 3H) 1.48(d, *J* = 7.1Hz, 3H) 1.39(d, *J* = 6.1Hz, 3H)

ESI-MS *m/z* 493 (MH⁺)

[0240]

Example 2

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that (R)-1-phenylethan-1-amine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (DMSO-d₆)δ: 8.35(d, *J* = 7.8Hz, 1H) 8.17-8.13(m, 1H) 7.48-7.23(m, 5H) 6.76-6.46(m, 1H) 6.28-6.06(m, 1H) 5.81-5.58(m, 1H) 5.43-5.02(m, 2H) 4.42-4.28(m, 1H) 4.21-3.96(m, 2H) 2.74-2.59(m, 1H) 2.54-2.41(m, 1H) 2.17(s, 3H) 1.50(d, *J* = 6.8Hz, 3H) 1.42-1.33(m, 3H)

ESI-MS *m/z* 457 (MH⁺)

[0241]

Example 3

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(2-phenylpropan-2-yl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that 2-phenylpropan-2-amine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (DMSO-d₆)δ: 8.26(s, 1H) 8.16-8.08(m, 1H) 7.44(dd, *J* = 8.8, 1.2Hz, 2H) 7.38-7.28(m, 2H) 7.21(tt, *J* = 7.3, 1.27Hz, 1H) 6.76-6.50(m, 1H) 6.25-6.10(m, 1H) 5.79-5.62(m, 1H) 5.45-5.19(m, 1H) 4.45-4.30(m, 1H) 4.26-4.01(m, 2H) 2.79-2.42(m, 2H) 2.29-2.22(m, 3H) 1.71(s, 6H) 1.43-1.36(m, 3H)

ESI-MS *m/z* 471 (MH⁺)

[0242]

Example 4

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylpropyl)-6-

(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that (R)-1-phenylpropan-1-amine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (DMSO-d₆)δ: 8.35(brd, *J* = 8.0Hz, 1H) 8.17-8.11(m, 1H) 7.46-7.22(m, 5H) 6.74-6.50(m, 1H) 6.26-6.08(m, 1H) 5.79-5.60(m, 1H) 5.40-5.21(m, 1H) 4.99-4.87(m, 1H) 4.43-4.30(m, 1H) 4.23-3.94(m, 2H) 2.76-2.42(m, 2H) 2.21(s, 3H) 1.95-1.74(m, 2H) 1.44-1.34(m, 3H) 0.91(t, *J* = 7.3Hz, 3H)

ESI-MS *m/z* 471 (MH⁺)

[0243]

Example 5

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(2-(2-fluorophenyl)propan-2-yl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that 2-(2-fluorophenyl)propan-2-amine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (CDCl₃)δ: 8.28(s, 1H) 8.11(d, *J* = 4.4Hz, 1H) 8.02(s, 1H) 7.47-7.42(m, 1H) 7.29-7.23(m, 1H) 7.15(t, *J* = 7.7Hz, 1H) 7.02(ddd, *J* = 12.5, 8.1, 1.1Hz, 1H) 6.58-6.35(m, 2H) 5.79-5.70(m, 1H) 5.30-5.19(m, 1H) 4.53(t, *J* = 10.1Hz, 0.7H) 4.38-4.25(m, 1.6H) 3.92(t, *J* = 8.8Hz, 0.7H) 2.91-2.78(m, 1H) 2.70-2.60(m, 0.3H) 2.54-2.43(m, 0.7H) 2.28(d, *J* = 7.0Hz, 3H) 1.88(dt, *J* = 10.0, 5.0Hz, 6H) 1.53(t, *J* = 6.2Hz, 3H)

ESI-MS *m/z* 489 (MH⁺)

[0244]

Example 6

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-(3-chlorophenyl)ethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that (R)-(+)-1-(3-chlorophenyl)ethylamine hydrochloride was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (CDCl₃)δ: 8.22(d, *J* = 5.9Hz, 1H) 7.75(d, *J* = 7.0Hz, 1H) 7.38(s, 1H) 7.35-7.27(m, 3H) 6.58-6.33(m, 2H) 5.78-5.66(m, 1H) 5.29-5.19(m, 2H) 4.56(t, *J* = 10.3Hz, 0.7H) 4.39-4.20(m, 1.6H) 3.89(t, *J* = 8.8Hz, 0.7H) 2.94-2.82(m, 1H) 2.66-2.58(m, 0.3H) 2.46(dt, *J* = 14.5, 6.1Hz, 0.7H) 2.18(d, *J* = 11.0Hz, 3H) 1.60(d, *J* = 7.0Hz, 3H) 1.55-1.51(m, 3H)

ESI-MS *m/z* 491, 493 (MH⁺)

[0245]

Example 7

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-(2,4-difluorophenyl)ethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that (R)-(+)-1-(2,4-difluorophenyl)ethylamine hydrochloride was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (CDCl₃)δ: 8.20(d, *J* = 5.9Hz, 1H) 7.98(d, *J* = 7.7Hz, 1H) 7.37-7.31(m, 1H) 6.90-6.81(m, 2H) 6.58-6.35(m, 2H) 5.78-5.65(m, 1H) 5.44-5.37(m, 1H) 5.30-5.19(m, 1H) 4.56(t, *J* = 10.1Hz, 0.7H) 4.38-4.23(m, 1.6H) 3.88(t, *J* = 8.8Hz, 0.7H) 2.94-2.83(m, 1H) 2.66-2.57(m, 0.3H) 2.51-2.42(m, 0.7H) 2.27(d, *J* = 9.2Hz, 3H) 1.61(d, *J* = 7.0Hz, 3H) 1.56-1.51(m, 3H)

ESI-MS *m/z* 493 (MH⁺)

[0246]

Example 8

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(prop-1-yn-1-yl)-N-((S)-2,2,2-trifluoro-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that (S)-2,2,2-trifluoro-1-phenylethan-1-amine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (CDCl₃)δ: 8.40(d, *J* = 8.8Hz, 1H) 8.16(s, 1H) 7.44(s, 5H) 6.58-6.38(m, 2H) 5.92-5.84(m, 1H) 5.81-5.69(m, 1H) 5.29-5.19(m, 1H) 4.55(t, *J* = 10.3Hz, 0.7H) 4.41-4.24(m, 1.6H) 3.91(t, *J* = 8.6Hz, 0.7H) 2.92-2.80(m, 1H) 2.70-2.61(m, 0.3H) 2.54-2.46(m, 0.7H) 2.35(d, *J* = 8.4Hz, 3H) 1.54(t, *J* = 7.3Hz, 3H)

ESI-MS *m/z* 511 (MH⁺)

[0247]

Example 9

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-(2-phenylpropan-2-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exceptions that cyclopropylacetylene was used instead of 1.0 M propyne in DMF solution in Example 1(3), and that 2-phenylpropan-2-amine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (CDCl₃)δ: 8.15(s, 1H) 8.00(s, 1H) 7.44(d, *J* = 7.7Hz, 2H) 7.37(t, *J* = 7.7Hz, 2H) 7.32-7.27(m, 1H) 6.66-6.30(m, 2H) 5.81-5.69(m, 1H) 5.38-5.24(m, 1H) 4.48(t, *J* = 9.9Hz, 0.7H) 4.42-4.29(m, 1.6H) 4.22(t, *J* = 10.4Hz, 0.7H) 2.77-2.68(m, 1H) 2.67-2.60(m, 0.3H) 2.59-2.52(m, 0.7H) 1.83(s, 6H) 1.60-1.52(m, 4H) 1.08-1.01(m, 2H) 0.92-0.88(m, 2H)

ESI-MS m/z 497 (MH⁺)

[0248]

Example 10

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-(2,3-difluorophenyl)ethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exceptions that cyclopropylacetylene was used instead of 1.0 M propyne in DMF solution in Example 1(3), and that (R)-(+)-1-(2,3-difluorophenyl)ethylamine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (CDCl₃)δ: 8.17(d, *J* = 4.0Hz, 1H) 8.04(d, *J* = 8.1Hz, 1H) 7.15-7.05(m, 3H) 6.58-6.36(m, 2H) 5.80-5.68(m, 1H) 5.49-5.42(m, 1H) 5.34-5.24(m, 1H) 4.52(t, *J* = 10.1Hz, 0.7H) 4.37-4.23(m, 1.6H) 3.92(t, *J* = 8.8Hz, 0.7H) 2.86-2.76(m, 1H) 2.69-2.63(m, 0.3H) 2.52-2.46(m, 0.7H) 1.73-1.63(m, 4H) 1.55(t, *J* = 5.3Hz, 3H) 1.14-1.07(m, 2H) 1.01-0.92(m, 2H)

ESI-MS m/z 519 (MH⁺)

[0249]

Example 11

Example 11(1)

tert-Butyl(2S,4R)-4-(4-amino-6-bromo-5-(((R)-1-phenylethyl)carbamoyl)-7H-pyrrolo[2,3-d]pyrimidin-7-yl)-2-methylpyrrolidine-1-carboxylate

The compound of Reference Example 1(2) (1.00 g), (R)-(+)-1-phenylethylamine (0.503 g), diisopropylethylamine (1.79 g), and N,N-dimethylformamide (10 mL) were added, and subsequently, HATU (1.58 g) was added. The obtained mixture was stirred at room temperature overnight. Thereafter, to the reaction mixture, ethyl acetate and a saturated sodium hydrogen carbonate aqueous solution were added, and the obtained mixture was then extracted with ethyl acetate. The gathered organic layer was washed with water, and then with saturated saline. The resultant was dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain an amide form (1.53 g). The obtained compound was used in the subsequent reaction without being further purified.

To the amide form (1.53 g), chloroform (15 mL) was added, and the obtained mixture was then cooled to 0°C. Thereafter, N-bromosuccinimide (0.88 g) was added to the reaction mixture, and the obtained mixture was then stirred at 0°C for 1 hour. Thereafter, the reaction mixture was concentrated under reduced pressure, and the obtained residue was purified by silica gel chromatography (hexane : ethyl acetate) to obtain a product of interest (1.39 g).

¹HNMR (CDCl₃)δ: 8.21 (s, 1H) 7.42-7.28(m,5H) 6.97(d,*J* = 7.3Hz,1H) 5.36-5.29(m,1H) 5.20-5.07(m,1H) 4.30(t,*J* = 10.3Hz,1H) 4.04-3.72(m,2H) 3.00-2.86(m,1H) 2.38(dt,*J* = 14.3,6.0Hz,1H) 1.63(d,*J* = 7.0Hz,3H) 1.53-1.43(m,12H)

ESI-MS *m/z* 543,545 (MH⁺)

[0250]

Example 11(2)

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-bromo-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

To the compound of Example 11(1) (600 mg), chloroform(3 mL) was added, and the obtained mixture was then cooled to 0°C. Thereafter, trifluoroacetic acid (4.44 g) was added to the reaction mixture, and the thus obtained mixture was then stirred at room temperature for 1 hour. Thereafter, the reaction mixture was concentrated under reduced pressure, and acetonitrile (5 mL) was then added to the residue. The obtained mixture was concentrated under reduced pressure again to obtain an amine form. The obtained compound was used in the subsequent reaction without being further purified.

To the obtained amine form, acetonitrile (3 mL) was added, and the obtained mixture was then cooled to 0°C. Thereafter, acryloyl chloride (99.9 mg) and diisopropylethylamine (713 mg) were added, and the obtained mixture was then stirred at 0°C for 1 hour. Thereafter, the reaction mixture was concentrated under reduced pressure, and the obtained residue was purified by silica gel chromatography (ethyl acetate : methanol) to obtain a product of interest (281 mg).

¹HNMR (CDCl₃)δ: 8.20(d,*J* = 7.3Hz,1H) 7.42-7.36(m,4H) 7.32-7.28(m,1H) 7.00-6.94(m,1H) 6.57-6.33(m,2H) 5.76-5.66(m,1H) 5.36-5.29(m, 1H) 5.14-5.08(m,1H) 4.71(t,*J* = 9.9Hz,0.7H) 4.42-4.23(m,1.6H) 3.83(t,*J* = 8.6Hz,0.7H) 3.03-2.92(m,1H) 2.60-2.57(m,0.3H) 2.44-2.40(m, 0.7H) 1.64(d,*J* = 6.6Hz,3H) 1.56(dd,*J* = 11.7,6.2Hz,3H)

ESI-MS *m/z* 497,499 (MH⁺)

[0251]

Example 11(3)

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The compound of Example 11(2) (65 mg), dichlorobis(triphenylphosphine)palladium (9.2 mg), copper(I) iodide (5.0 mg), cyclopropylacetylene (13.0 mg), triethylamine (39.7 mg), and N,N-dimethylformamide (1.3 mL) were added, and the inside of the reaction system was then substituted with nitrogen. After that, the mixture was stirred at 70°C for 2.5 hours. Thereafter, to the reaction mixture, ethyl acetate and a saturated ammonium chloride aqueous solution were

added, and the obtained mixture was then extracted with ethyl acetate. The gathered organic layer was washed with water, and then with saturated saline. The resultant was dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (chloroform : methanol) to obtain a product of interest (50 mg).

¹HNMR (CDCl₃)δ: 8.22(d, *J* = 5.1Hz, 1H) 7.82(d, *J* = 7.3Hz, 1H) 7.43-7.35(m, 4H) 7.30(t, *J* = 6.8Hz, 1H) 6.58-6.34(m, 2H) 5.77-5.66(m, 1H) 5.35-5.20(m, 2H) 4.54(t, *J* = 10.1Hz, 0.7H) 4.35-4.25(m, 1.6H) 3.88(t, *J* = 8.8Hz, 0.7H) 2.90-2.78(m, 1H) 2.65-2.56(m, 0.3H) 2.49-2.40(m, 0.7H) 1.63(d, *J* = 7.0Hz, 3H) 1.56-1.45(m, 4H) 1.03-0.91(m, 2H) 0.84-0.69(m, 2H)

ESI-MS *m/z* 483 (MH⁺)

[0252]

Example 12

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(3,3-dimethylbut-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 11, with the exception that 3,3-dimethyl-1-butyne was used instead of cyclopropylacetylene in Example 11(3).

¹HNMR (CDCl₃)δ: 8.22(d, *J* = 5.9Hz, 1H) 7.75(d, *J* = 7.7Hz, 1H) 7.38(dt, *J* = 15.5, 7.1Hz, 4H) 7.31-7.25(m, 1H) 6.57-6.34(m, 2H) 5.77-5.65(m, 1H) 5.44-5.35(m, 1H) 5.33-5.15(m, 1H) 4.63(t, *J* = 10.1Hz, 0.7H) 4.40-4.20(m, 1.6H) 3.89(t, *J* = 8.8Hz, 0.7H) 2.90-2.76(m, 1H) 2.65-2.55(m, 0.3H) 2.49-2.40(m, 0.7H) 1.85(s, 1H) 1.64(d, *J* = 7.0Hz, 3H) 1.55(d, *J* = 5.9Hz, 3H) 1.26(s, 9H)

ESI-MS *m/z* 499 (MH⁺)

[0253]

Example 13

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(3-methoxy-3-methylbut-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 11, with the exception that 3-methoxy-3-methyl-1-butyne was used instead of cyclopropylacetylene in Example 11(3).

¹HNMR (CDCl₃)δ: 8.17 (s, 1H) 7.61(d, *J* = 7.7Hz, 1H) 7.43-7.35(m, 4H) 7.30(d, *J* = 7.0Hz, 1H) 6.57-6.33(m, 2H) 5.81-5.68(m, 1H) 5.43-5.33(m, 1H) 5.29-5.12(m, 1H) 4.59(t, *J* = 10.1Hz, 0.7H) 4.38-4.22(m, 1.6H) 3.92(t, *J* = 8.6Hz, 0.7H) 3.30(s, 3H) 2.86-2.72(m, 1H) 2.70-2.60(m, 1.3H) 2.52-2.44(m, 0.7H) 1.64(d, *J* = 7.0Hz, 3H) 1.55(t, *J* = 5.5Hz, 3H) 1.46(d, *J* = 2.2Hz, 6H)

ESI-MS m/z 515 (MH⁺)

[0254]

Example 14

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(but-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 11, with the exception that 1-trimethylsilyl-1-butyne and tetra-*n*-butylammonium fluoride were used instead of cyclopropylacetylene in Example 11(3).

¹HNMR (CDCl₃) δ : 8.26-8.25(m,1H) 7.79(d, J = 7.3Hz,1H) 7.42-7.36(m,4H) 7.32-7.30(m,1H) 6.57-6.37(m,2H) 5.76-5.66(m,1H) 5.33-5.20(m,2H) 4.57(t, J = 10.3Hz,0.7H) 4.36-4.22(m,1.6H) 3.88(t, J = 8.8Hz,0.7H) 2.92-2.81(m,1H) 2.65-2.57(m,0.3H) 2.48-2.38(m,2.7H) 1.63(d, J = 7.0Hz,3H) 1.54-1.51(m,3H) 1.17-1.12(m,3H)

ESI-MS m/z 471 (MH⁺)

[0255]

Example 15

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(2-(2-fluorophenyl)propan-2-yl)-6-(3-methylbut-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 11, with the exceptions that 2-(2-fluorophenyl)propan-2-amine was used instead of (R)-(+)-1-phenylethylamine in Example 11(1), and that 3-methyl-1-butyne was used instead of cyclopropylacetylene in Example 11(3).

¹HNMR (CDCl₃) δ : 7.92 (s, 1H) 7.44(t, J = 7.9Hz,1H) 7.30-7.23(m,1H) 7.14(t, J = 7.5Hz,1H) 7.02(dd, J = 12.6,8.2Hz,1H) 6.58-6.35(m,2H) 5.80-5.69(m,1H) 5.33-5.16(m,1H) 4.58(t, J = 9.9Hz,0.7H) 4.38-4.23(m,1.6H) 3.91(t, J = 8.4Hz,0.7H) 3.03-2.93(m,1H) 2.89-2.75(m,1H) 2.69-2.60(m,0.3H) 2.53-2.43(m,0.7H) 1.88(s,6H) 1.55(d, J = 5.1Hz,3H) 1.36(d, J = 6.6Hz,6H)

ESI-MS m/z 517 (MH⁺)

[0256]

Example 16

Example 16(1)

tert-Butyl (2R,4S)-4-(benzyloxy)-2-((tosyloxy)methyl)pyrrolidine-1-carboxylate

tert-Butyl (2R,4S)-4-(benzyloxy)-2-(hydroxymethyl)pyrrolidine-1-carboxylate (2.0 g) was dissolved in methylene chloride (20 mL), and the obtained solution was then cooled to 0°C. Thereafter, 1,4-diazabicyclo[2.2.2]octane (2.2 g) and tosylate chloride (1.9 g) were added to the reaction solution, and the temperature of the mixture was then increased to room temperature. The mixture was stirred for 4 hours. Thereafter, a

saturated sodium hydrogen carbonate aqueous solution was added to the reaction mixture, and the obtained mixture was then extracted with ethyl acetate. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : ethyl acetate) to obtain a product of interest (4.32 g).

^1H NMR (CDCl_3) δ : 7.78(d, $J = 8.1\text{Hz}$, 2H), 7.42-7.29(m, 7H), 4.57-4.41(m, 2H), 4.39-3.96(m, 4H), 3.61-3.20(m, 2H), 2.46(s, 3H), 2.27-2.02(m, 2H), 1.48-1.31(m, 9H)

ESI-MS m/z 462 (MH^+)

[0257]

Example 16(2)

tert-Butyl (2S,4S)-4-(benzyloxy)-2-ethylpyrrolidine-1-carboxylate

Under a nitrogen atmosphere, copper iodide (2.04 g) was suspended in diethyl ether (12 mL), and the obtained suspension was then cooled to 0°C . Thereafter, 1.04 M methyl lithium in diethyl ether solution (0.36 mL) was added, and the obtained mixture was then stirred at 0°C for 30 minutes. Subsequently, the compound of Example 16(1) (1.98 g) in methylene chloride (4.0 mL) solution was added to the reaction mixture, and the temperature of the obtained mixture was then increased to room temperature. The mixture was stirred for 1 hour. Thereafter, the reaction mixture was cooled to 0°C , and a saturated ammonium chloride aqueous solution was then added to the reaction mixture. The thus obtained mixture was extracted with ethyl acetate. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : ethyl acetate) to obtain a product of interest (707 mg).

^1H NMR (CDCl_3) δ 7.42-7.25(m, 5H), 4.66-4.40(m, 2H), 4.17-4.03(m, 1H), 4.00-3.26(m, 3H), 2.24-2.09(m, 1H), 1.96-1.71(m, 2H), 1.48(s, 9H), 1.45-1.31(m, 1H), 0.86(t, $J = 7.4\text{Hz}$, 3H)

ESI-MS m/z 306 (MH^+)

[0258]

Example 16(3)

tert-Butyl (2S,4S)-2-ethyl-4-hydroxypyrrolidine-1-carboxylate

The compound of Example 16(2) (1.06 g) and a 10% palladium hydroxide carbon catalyst (160 mg) were suspended in ethanol (11 mL) and THF (11 mL), followed by hydrogen substitution, and the resultant was then stirred at room temperature for 20 hours. Thereafter, the reaction mixture was filtrated through Celite, and was then washed with ethanol, and the filtrate was then concentrated under reduced pressure. The

obtained residue was purified by silica gel chromatography (hexane : ethyl acetate) to obtain a product of interest (709 mg).

¹HNMR (CDCl₃)δ 4.46-4.36(m,1H), 4.02-3.81(m,1H), 3.71-3.35(m,2H), 2.15-1.99(m,1H), 1.95-1.72(m,2H), 1.49(s,9H), 1.46-1.35(m,1H), 0.86(t,J = 7.5Hz,3H)

ESI-MS m/z 216 (MH⁺)

[0259]

Example 16(4)

tert-Butyl (2S,4R)-4-(4-chloro-5-iodo-7H-pyrrolo[2,3-d]pyrimidin-7-yl)-2-ethylpyrrolidine-1-carboxylate

The compound of Example 16(3) (709 mg) and 4-chloro-5-iodo-7H-pyrrolo[2,3-d]pyrimidine (1.11 g) were dissolved in THF (7.1 mL), and the obtained solution was then cooled to 0°C. Thereafter, triphenylphosphine (1.3 g) and diisopropyl azodicarboxylate (1.00 mL) were added, and the temperature of the obtained mixture was then increased to room temperature, followed by stirring the mixture for 1 hour. Thereafter, the reaction mixture was concentrated under reduced pressure, and the obtained residue was then purified by silica gel chromatography (hexane : ethyl acetate) to obtain the corresponding coupling body. The obtained compound was used in the subsequent reaction without being further purified. Into a pressure resistant tube, the obtained coupling body, THF (5.4 mL), and ammonia water (5.4 mL) were added, and the obtained mixture was then stirred at 100°C for 14 hours. Thereafter, the reaction mixture was cooled to room temperature, and was then poured into water (12.8 mL), and the mixed solution was then extracted with ethyl acetate. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain a product of interest (797 mg).

¹HNMR (CDCl₃)δ 8.29(s,1H), 7.14(s,1H), 5.67(br s,2H), 5.32-5.09(m,1H), 4.24-4.08(m,1H), 3.95-3.79(m,1H), 3.46(dd,J = 9.3,11.0Hz,1H), 2.70-2.55(m,1H), 2.06-1.95(m,1H), 1.59-1.51(m,2H), 1.49(s,9H), 0.91(t,J = 7.5Hz,3H)

ESI-MS m/z 458 (MH⁺)

[0260]

Example 16(5)

tert-Butyl (2S,4R)-4-(4-amino-6-bromo-5-(((R)-1-phenylethyl)carbamoyl)-7H-pyrrolo[2,3-d]pyrimidin-7-yl)-2-ethylpyrrolidine-1-carboxylate

The compound of Example 16(4) (797 mg), dichlorobis(triphenylphosphine)palladium (25 mg), and (R)-(+)-1-phenylethylamine (0.55 mL) were suspended in DMF (8.0 mL), followed by carbon monoxide substitution,

and the resultant was then stirred at 80°C for 2 hours. Thereafter, the reaction mixture was cooled to room temperature, water was then added thereto, and the obtained mixture was then extracted with ethyl acetate. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain the corresponding amide form. The obtained compound was used in the subsequent reaction without being further purified. The obtained amide form was dissolved in acetonitrile (8.2 mL), and the obtained solution was then cooled to -10°C. Thereafter, N-bromosuccinimide (457 mg) in acetonitrile (8.2 mL) solution was slowly added dropwise to the solution, and the reaction mixture was then stirred for 30 minutes. Thereafter, to the reaction mixture, a sodium sulfite aqueous solution and a sodium hydrogen carbonate aqueous solution were added, and the obtained mixture was then extracted with ethyl acetate. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain a product of interest (650 mg).

¹HNMR (CDCl₃) δ 8.23(s,1H), 7.49-7.29(m,5H), 6.98(d,J = 7.4Hz,1H), 5.41-5.28(m,1H), 5.24-5.04(m,1H), 4.38-4.22(m,1H), 4.07-3.68(m,1H), 3.19-2.83(m,1H), 2.43-2.29(m,1H), 2.25-1.67(m,3H), 1.66(d,J = 6.9Hz,3H), 1.51(s,9H), 0.98(t,J = 7.4Hz,3H)
ESI-MS m/z 557,559 (MH⁺)

[0261]

Example 16(6)

7-((3R,5S)-1-acryloyl-5-ethylpyrrolidin-3-yl)-4-amino-6-bromo-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

To the compound of Example 16(5) (650 mg), acetonitrile (9.7 mL) was added, and the obtained mixture was then cooled to 0°C. Thereafter, sodium iodide (1.05 g) and trimethylsilyl chloride (0.89 mL) were added, and the obtained mixture was then stirred at 0°C for 1 hour. Thereafter, to the reaction mixture, ethanol (9.7 mL), isopropylethylamine (2.0 mL), and acrylic acid anhydride (0.16 mL) were successively added, and the obtained mixture was then stirred at 0°C for 30 minutes. Thereafter, to the reaction mixture, ammonia water and water were added, and the obtained mixture was then extracted with ethyl acetate. The gathered organic layer was washed with saturated saline, was then dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : acetone) to obtain a product of interest (256 mg).

¹HNMR (CDCl₃) δ 8.27-8.16(m,1H), 7.47-7.29(m,5H), 6.98(d,J = 7.3Hz,1H), 6.61-

6.29(m,2H), 5.84-5.63(m,1H), 5.43-5.26(m,1H), 5.22-5.01(m,1H), 4.80-3.82(m,3H), 3.23-2.92(m,1H), 2.58-2.30(m,1H), 2.22-1.79(m,2H), 1.66(d, J = 7.0Hz, 3H), 1.07-0.96(m,3H)

ESI-MS m/z 511, 513 (MH⁺)

[0262]

Example 16(7)

7-((3R,5S)-1-acryloyl-5-ethylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

1.0 M Propyne in DMF solution (0.70 mL) was added to the compound of Example 16(6) (120 mg), acetonitrile (1.2 mL), triethylamine (0.10 mL), PdCl₂(PPh₃)₂ (8.2 mg), and copper(I) iodide (0.4 mg), followed by nitrogen substitution, and the mixture was then stirred at 60°C for 2 hours. Thereafter, the reaction mixture was cooled to room temperature, and ethyl acetate and a saturated ammonium chloride aqueous solution were added to the mixture. The thus obtained mixture was extracted with ethyl acetate, and the gathered organic layer was washed with water, and then with saturated saline. The resultant was dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (ethyl acetate : methanol) to obtain a product of interest (102 mg).

¹HNMR (CDCl₃)δ: 8.26(s,1H), 7.79(br d, J = 7.0Hz, 1H), 7.46-7.30(m,5H), 6.58-6.31(m,2H), 5.80-5.65(m,1H), 5.33-5.15(m,2H), 4.59-3.85(m,3H), 3.03-2.33(m,2H), 2.25-1.70(m,5H), 1.65(d, J = 6.8Hz, 6H), 1.09-0.91(m,3H)

ESI-MS m/z 471 (MH⁺)

[0263]

Example 17

7-((3R,5S)-1-acryloyl-5-ethylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 16, with the exception that cyclopropylacetylene was used instead of 1.0 M propyne in DMF solution in Example 16(7).

¹HNMR (CDCl₃)δ: 8.31-8.16(m,1H), 7.84(d, J = 7.4Hz, 1H), 7.46-7.30(m,5H), 6.64-6.32(m,2H), 5.82-5.67(m,1H), 5.39-5.17(m,2H), 4.67-3.81(m,3H), 3.02-2.80(m,1H), 2.62-1.71(m,3H), 1.65(d, J = 6.9Hz, 3H), 1.58-1.47(m,1H), 1.06-0.92(m,5H), 0.85-0.70(m,2H)

ESI-MS m/z 497 (MH⁺)

[0264]

Example 18

7-((3R,5R)-1-acryloyl-5-(methoxymethyl)pyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 16, with the exceptions that tert-butyl (2R,4S)-4-hydroxy-2-(methoxymethyl)pyrrolidine-1-carboxylate was used instead of the compound of Example 16(3) in Example 16(4), and that cyclopropylacetylene was used instead of 1.0 M propyne in DMF solution in Example 16(7).

¹HNMR (CDCl₃)δ: 8.29-8.22(m,1H), 7.86-7.80(m,1H), 7.36-7.44(m,4H), 7.34-7.28(m,1H), 6.48-6.37(m,2H), 5.78-5.69(m,1H), 5.29-5.15(m,2H), 4.55-4.30(m,2H), 3.96-3.65(m,3H), 3.42(s,3H), 3.18-3.06(m,0.3H), 2.90-2.80(m,0.3H), 2.64-2.58(m,0.3H), 2.47-2.35(m,0.7H), 1.64(d,3H, J = 6.9Hz), 1.58-1.47(m,1H), 1.04-0.94(m,2H), 0.87-0.69(m,2H)

ESI-MS m/z 513 (MH⁺)

[0265]

Example 19

7-((3R,5R)-1-acryloyl-5-(ethoxymethyl)pyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 16, with the exceptions that tert-butyl (2R,4S)-2-(ethoxymethyl)-4-hydroxypyrrolidine-1-carboxamide was used instead of the compound of Example 16(3) in Example 16(4), and that cyclopropylacetylene was used instead of 1.0 M propyne in DMF solution in Example 16(7).

¹HNMR (CDCl₃)δ: 8.28-8.18(m,1H), 7.84(br d, J = 7.0Hz, 1H), 7.47-7.29(m,5H), 6.82-6.35(m,2H), 5.79-5.68(m,1H), 5.40-5.14(m,2H), 4.63-3.53(m,7H), 3.20-2.79(m,1H), 2.69-2.40(m,1H), 1.67-1.63(m,3H), 1.59-1.47(m,1H), 1.22(t, J = 7.0Hz, 3H), 1.05-0.92(m,2H), 0.87-0.72(m,2H)

ESI-MS m/z 527 (MH⁺)

[0266]

Comparative Example 1

4-Amino-N-(4-(methoxymethyl)phenyl)-7-(1-methylcyclopropyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained by the method described in Example 95 of International Publication No. WO 2017/146116.

ESI-MS m/z 390 (MH⁺)

[0267]

Comparative Example 2

1-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(4-(2-(dimethylamino)-2-oxoethyl)-2,3-dimethylphenyl)-1H-pyrazolo[3,4-d]pyrimidine-3-carboxamide

The title compound was obtained by the method described in Example 79 of International Publication No. WO 2017/038838.

ESI-MS m/z 505 (MH⁺)

[0268]

Comparative Example 3

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(cyclohexylmethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that cyclohexylmethanamine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (DMSO-d₆)δ:8.68-8.31(m,1H) 8.20-8.10(m,1H) 8.09-7.97(m,1H) 7.59-7.20(m,1H) 6.74-6.49(m,1H) 6.25-6.09(m,1H) 5.78-5.60(m,1H) 5.40-5.20(m,1H) 4.44-4.29(m,1H) 4.23-3.92(m,2H) 3.25-3.12(m,2H) 2.76-2.40(m,2H) 2.25(s,3H) 1.81-1.45(m,5H) 1.43-1.34(m,3H) 1.30-0.90(m,6H)

ESI-MS m/z 449 (MH⁺)

[0269]

Comparative Example 4

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-(2-methylbenzyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with the exception that o-tolylmethanamine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (DMSO-d₆)δ:8.37-8.27(m,1H) 8.19-8.09(m,1H) 7.39-7.30(m,1H) 7.26-7.11(m,4H) 6.68-6.48(m,1H) 6.24-6.07(m,1H) 5.80-5.60(m,1H) 5.36-5.17(m,1H) 4.52(d, J = 5.7Hz, 2H) 4.42-4.28(m,1H) 4.22-3.92(m,2H) 2.73-2.42(m,2H) 2.33(s,3H) 2.02(s,3H) 1.43-1.32(m,3H)

ESI-MS m/z 457 (MH⁺)

[0270]

Comparative Example 5

7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-methyl-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

The title compound was obtained in the same manner as that of Example 1, with

the exception that (R)-N-methyl-1-phenylethan-1-amine was used instead of (R)-1-(3,5-difluorophenyl)ethan-1-amine in Example 1(5).

¹HNMR (CDCl₃)δ: 8.23(d, *J* = 5.9Hz, 1H) 7.50-7.28(m, 4H) 7.09-6.88(m, 1H) 6.57-6.34(m, 2H) 5.79-5.64(m, 1H) 5.22(t, *J* = 9.3Hz, 1H) 4.48(t, *J* = 9.7Hz, 0.6H) 4.39-4.20(m, 1.9H) 3.90(t, *J* = 8.6Hz, 0.5H) 2.85(s, 4H) 2.66-2.63(m, 0.4H) 2.51-2.44(m, 0.6H) 2.07(s, 2H) 1.66(d, *J* = 4.8Hz, 3H) 1.52(d, *J* = 5.9Hz, 3H)

ESI-MS *m/z* 471 (MH⁺)

[0271]

Comparative Example 6(1)

tert-Butyl (2S,4R)-4-(4-amino-5-(((R)-1-phenylethyl)carbamoyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidin-7-yl)-2-methylpyrrolidine-1-carboxylate

1.0 M Propyne in DMF solution (2.1 mL) was added to the compound of Example 11(1) (230 mg), acetonitrile (4.6 mL), triethylamine (0.29 mL), PdCl₂(PPh₃)₂ (5.9 mg), and copper(I) iodide (1.6 mg), followed by nitrogen substitution, and the obtained mixture was then stirred at 70°C for 1 hour. Thereafter, the reaction mixture was cooled to room temperature, and ethyl acetate and a saturated sodium hydrogen carbonate aqueous solution were then added to the mixture. The thus obtained mixture was extracted with ethyl acetate, and the gathered organic layer was washed with water and then with saturated saline. The resultant was dried over anhydrous sodium sulfate, and was then concentrated under reduced pressure. The obtained residue was purified by silica gel chromatography (hexane : ethyl acetate) to obtain a product of interest (193 mg).

¹HNMR (CDCl₃)δ: 8.23 (s, 1H) 7.79(d, *J* = 6.8Hz, 1H) 7.46-7.27(m, 5H) 5.40-5.17(m, 2H) 4.28-3.64(m, 3H) 2.85-2.68(m, 1H) 2.46-2.36(m, 1H) 2.15-1.97(m, 3H) 1.62(d, *J* = 6.8Hz, 3H) 1.56-1.32(m, 12H)

ESI-MS *m/z* 503 (MH⁺)

[0272]

Comparative Example 6(2)

4-Amino-7-((3R,5S)-5-methylpyrrolidin-3-yl)-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide hydrochloride

To the compound of Comparative Example 6(1) (530 mg), 4 M hydrochloric acid in 1,4-dioxane solution (5 mL) was added, and the obtained mixture was then stirred at room temperature for 2 hours. Thereafter, the reaction mixture was concentrated under reduced pressure to obtain a product of interest (420 mg).

ESI-MS *m/z* 403 (MH⁺)

[0273]

Comparative Example 6(3)

4-Amino-7-((3R,5S)-1-((E)-but-2-enoyl)-5-methylpyrrolidin-3-yl)-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide

To the compound of Comparative Example 6(2) (18 mg), acetonitrile (0.5 mL) was added, and the obtained mixture was then cooled to 0°C. Thereafter, acryloyl chloride (0.004 mL) and diisopropylethylamine (0.036 mL) were added to the reaction mixture, and the thus obtained mixture was then stirred at 0°C for 1 hour. Thereafter, the reaction mixture was concentrated under reduced pressure, and was then subjected to reverse phase preparative HPLC (water : acetonitrile (0.1% formic acid)) to obtain a product of interest (8.7 mg).

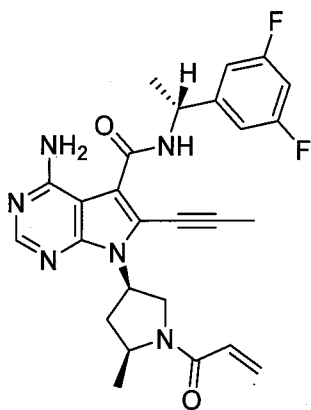
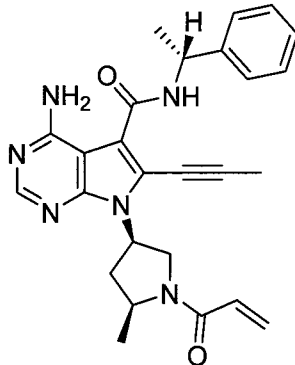
¹HNMR (CDCl₃)δ: 8.31 (s, 1H) 8.14(d, *J* = 6.2Hz, 1H) 7.77(d, *J* = 7.0Hz, 1H) 7.39-7.36(m, 4H) 7.33-7.31(m, 1H) 7.03-6.90(m, 1H) 6.06(dd, *J* = 14.3Hz, 1H) 5.28-5.17(m, 2H) 4.48(t, *J* = 10.1Hz, 1H) 4.35-4.20(m, 2H) 3.88(t, 8.8Hz, 1H) 2.84-2.76(m, 1H) 2.64-2.40(m, 1H) 2.05(d, *J* = 10.6Hz, 3H) 1.92(d, *J* = 6.6Hz, 1H) 1.85(d, *J* = 7.0Hz, 2H) 1.62(d, *J* = 7.0Hz, 3H) 1.55(dd, *J* = 9.0, 5.7Hz, 3H)

ESI-MS *m/z* 471 (MH⁺)

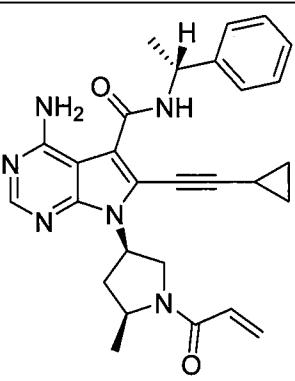
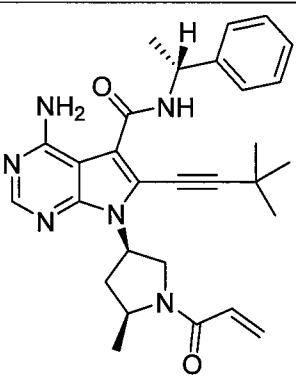
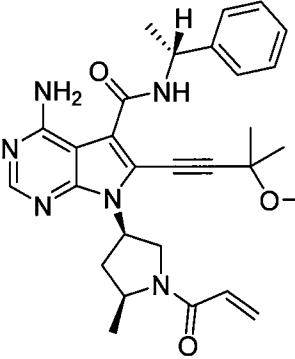
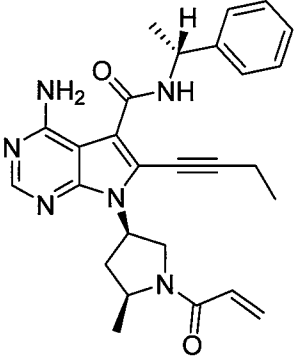
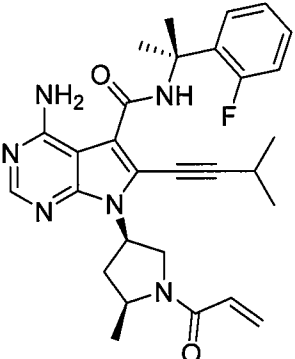
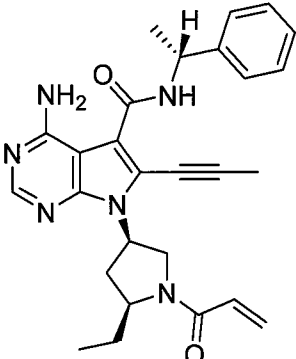
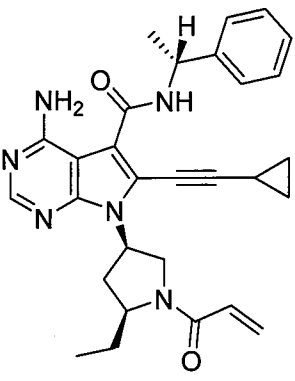
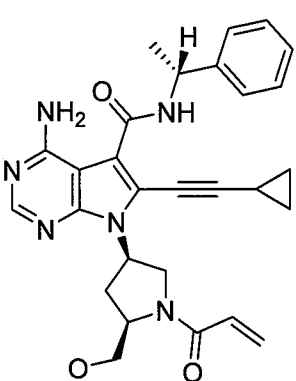
[0274]

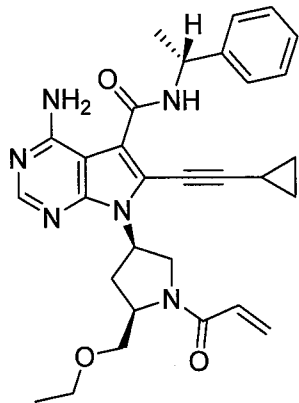
The compounds synthesized in the above-described Examples and Comparative Examples are shown below.

[Table 1]

Examp le No.	Structural Formula	Examp le No.	Structural Formula
1		2	

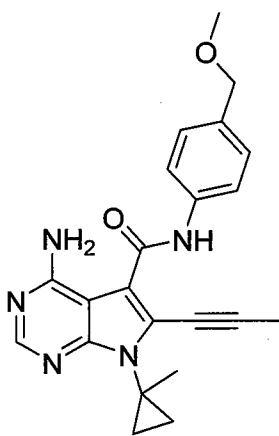
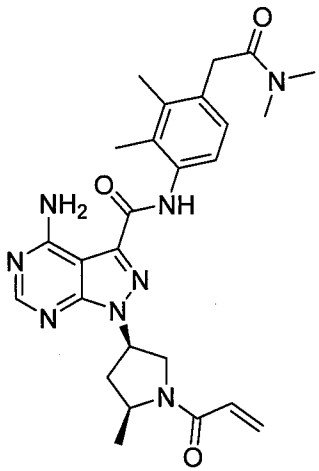
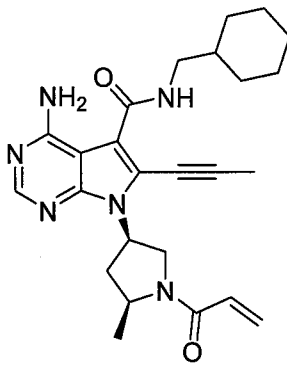
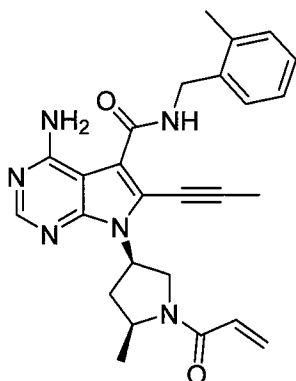
3		4	
5		6	
7		8	
9		10	

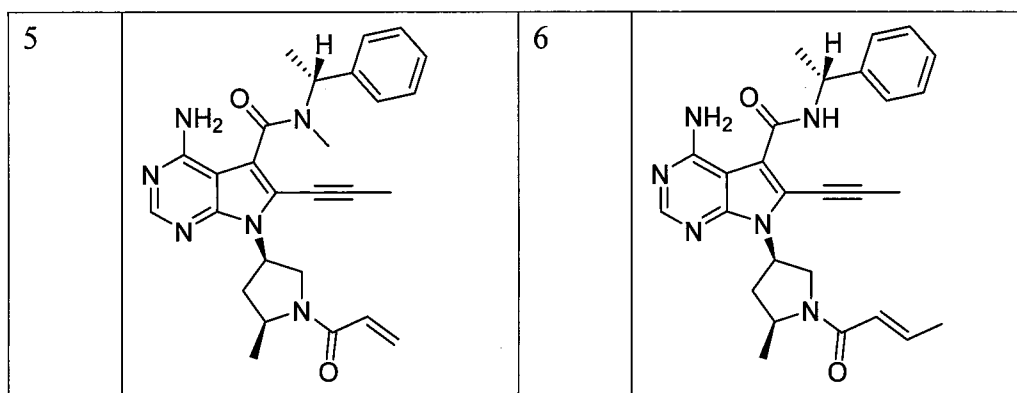
11		12	
13		14	
15		16	
17		18	

19			
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[0275]

[Table 2]

Comp . Ex. No.	Structural Formula	Comp . Ex. No.	Structural Formula
1		2	
3		4	



[0276]

Test Example 1 Measurement of inhibitory effect (*in vitro*) on HER2 phosphorylation activity

In order to determine conditions for a method of measuring the *in vitro* inhibitory activity of a compound against HER2 phosphorylation activity, based on the report regarding a HER2 kinase reaction using, as a substrate, a peptide having the same sequence (5-FAM-EEPLYWSFPAKKK-CONH₂) as that of ProfilerPro Peptide 22 of PerkinElmer (Xie H et al., PLoS One.2011; 6(7): e21487), ProfilerPro Peptide 22 was used as a substrate. A purified recombinant human HER2 protein used in the present test was purchased from Carna Biosciences, Inc. Upon the measurement of the inhibitory activity of the pyrimidine compound, first, the compound of the present invention was diluted stepwise with dimethyl sulfoxide (DMSO). Subsequently, the HER2 protein, the substrate peptide (final concentration: 1 μ M), manganese chloride (final concentration: 10 mM), ATP (final concentration: 5 μ M), and the pyrimidine compound of the present invention in DMSO solution (final concentration of DMSO: 5%) were added to a buffer for the kinase reaction (13.5 mM Tris (pH 7.5), 2 mM dithiothreitol, and 0.009% Tween 20), and the obtained mixture was then incubated at 25°C for 30 minutes, so that the kinase reaction was carried out. To the reaction solution, EDTA was added to a final concentration of 30 mM, so as to terminate the reaction. Finally, using LabChip (registered trademark) EZ Reader II (PerkinElmer), an unphosphorylated substrate peptide (S) and a phosphorylated peptide (P) were separated and detected according to microchannel capillary electrophoresis. From the peak heights of S and P, the amount of the phosphorylation reaction was obtained, and the concentration of the compound capable of inhibiting the phosphorylation reaction by 50% was defined as an IC₅₀ value (nM). The results are shown in Table 3.

[0277]

Test Example 2 Measurement of inhibitory action (*in vitro*) against HER2 exon 20

insertion mutant (HER2ex20insYVMA) phosphorylation activity

In order to determine conditions for a method of measuring the *in vitro* inhibitory activity of a compound against HER2 exon 20 insertion mutant phosphorylation activity, as in the case of HER2, ProfilerPro Peptide 22 was used as a substrate. A purified recombinant human HER2 exon 20 insertion mutant (A775_G776insYVMA) protein was purchased from SignalChem. Upon the measurement of the inhibitory activity of the compound, first, the pyrimidine compound of the present invention was diluted stepwise with dimethyl sulfoxide (DMSO). Subsequently, the HER2 exon 20 insertion mutant protein and the pyrimidine compound of the present invention in DMSO solution (final concentration of DMSO: 5%) were added into a buffer for the kinase reaction (13.5 mM Tris (pH 7.5), 2 mM dithiothreitol, and 0.009% Tween 20), and the obtained mixture was then pre-incubated at 25°C for 30 minutes. Thereafter, the substrate peptide (final concentration: 1 μ M), manganese chloride (final concentration: 25 mM), magnesium chloride (final concentration: 20 mM), and ATP (final concentration: 200 μ M) were added into the reaction mixture, and the thus obtained mixture was then incubated at 25°C for 220 minutes, so that the kinase reaction was carried out. To the reaction solution, EDTA was added to a final concentration of 30 mM, so as to terminate the reaction. Finally, using LabChip (registered trademark) EZ Reader II (PerkinElmer), an unphosphorylated substrate peptide (S) and a phosphorylated peptide (P) were separated and detected according to microchannel capillary electrophoresis. From the peak heights of S and P, the amount of the phosphorylation reaction was obtained, and the concentration of the compound capable of inhibiting the phosphorylation reaction by 50% was defined as an IC₅₀ value (nM). The results are shown in Table 3.

[0278]

[Table 3]

Example No.	HER2 inhibitory activity IC ₅₀ value (nM)	HER2ex20insYVMA inhibitory activity IC ₅₀ value (nM)
1	2.7	0.34
2	2.5	< 0.30
3	5.8	< 0.30
4	3.9	0.37
5	7.7	0.38
6	2.8	< 0.30
7	4.9	0.39
8	10	< 0.30

9	5.6	0.32
10	2.2	< 0.30
11	3.2	< 0.30
12	3.4	0.39
13	5.2	0.44
14	2.2	< 0.30
15	4.6	0.42
16	3.3	0.44
17	2.9	0.54
18	2.3	< 0.30
19	4.4	1.1
Comp. Ex. 1	> 10000	> 10000
Comp. Ex. 2	19	4.4
Comp. Ex. 3	630	380
Comp. Ex. 4	54	11
Comp. Ex. 5	130	14
Comp. Ex. 6	390	> 10000

[0279]

From the above results, it was found that the pyrimidine compound of the present invention has excellent inhibitory activity against phosphorylation of HER2 and against phosphorylation of HER2 exon 20 insertion mutant.

[0280]

Test Example 3 Measurement of growth inhibitory activity against HER2 expressing cell line

SK-BR-3 cells as a HER2 overexpressing human breast cancer cell line were suspended in a McCoy's 5a medium (manufactured by Life Technologies) supplemented with 10% fetal bovine serum. The cell suspension was seeded in each well of a 384-well flat-bottom microplate, and was then cultured in a 5% carbon dioxide gas-containing culture vessel at 37°C for 1 day. Thereafter, the compound of the present invention was dissolved in DMSO, and the pyrimidine compound was diluted to 500 times the final concentration in DMSO. The compound in the DMSO solution was diluted with DMSO solution or the medium used in the suspension of the cells, and the obtained solution was then added to each well of the culture plate so that the final concentration of DMSO was 0.2%. The obtained mixture was further cultured in the 5% carbon dioxide gas-containing culture vessel at 37°C for 3 days. After completion of the culture for 3 days in the presence of the compound, the cells were counted using CellTiter-Glo 2.0

(manufactured by Promega), and the growth inhibition percentage was then calculated according to the following equation. The concentration of the compound, in which the growth of the cells can be inhibited by 50%, was defined as IC₅₀ (nM).

Growth inhibitory percentage (%) = (C-T) / (C) x 100

T: Emission intensity from the well to which the test compound was added

C: Emission intensity from the well to which the test compound was not added

The results are shown in the following Table 4.

[0281]

Test Example 4 Measurement of growth inhibitory activity against HER2 exon 20 insertion mutant expressing cell line

Growth inhibitory activity against the HER2 exon 20 insertion mutant was measured using Ba/F3 cells that were a mouse B lymphocyte precursor cell line, into which a human HER2 exon 20 insertion mutant gene had been introduced. The Ba/F3 cells were maintained in an RPMI-1640 medium (Thermo Fisher Scientific) supplemented with 10% fetal bovine serum (FBS), 100 U/mL penicillin, 100 µg/mL streptomycin (Thermo Fisher Scientific) and 1 ng/mL mouse interleukin-3 (mIL-3) (CST). Thereafter, a pCDNA3.1-hyg(+) vector, into which a human HER2 exon 20 insertion mutant gene (A775_G776insYVMA (HER2ex20insYVMA)), Internal Ribosome Binding Sequence (IRES), and a Kusabira orange gene had been incorporated, was introduced into the Ba/F3 cells according to an electroporation method using Amaxa (registered trademark) Cell Line Nucleofector (registered trademark) Kit V. The Ba/F3 cells expressing the HER2 exon 20 insertion mutant (Ba/F3-HER2insYVMA), which were selected with hygromycin B (Nacalai Tesque), exhibited mIL-3-independent growth.

Upon evaluation of cell growth inhibitory activity, the Ba/F3-HER2insYVMA cells were suspended in an RPMI-1640 medium supplemented with 10% FBS, 100 U/mL penicillin, and 100 µg/mL streptomycin. The cell suspension was seeded in each well of a 96-well flat-bottom microplate, and was then cultured in a 5% carbon dioxide gas-containing culture vessel at 37°C for 1 day. The pyrimidine compound of the present invention was dissolved in DMSO, and was then diluted with DMSO or the medium used in the suspension of the cells. The obtained solution was then added to each well of the culture plate, so that the final concentration of DMSO became 0.2%. The obtained mixture was further cultured in the 5% carbon dioxide gas-containing culture vessel at 37°C for 3 days. After completion of the culture for 3 days in the presence of the compound, the cells were counted using CellTiter-Glo 2.0 (manufactured by Promega), and the growth inhibition percentage was then calculated according to the following equation. The concentration of the compound, in which the growth of the cells can be

inhibited by 50%, was defined as IC₅₀ (nM).

Growth inhibitory percentage (%) = (C-T) / (C) x 100

T: Emission intensity from the well to which the test compound was added

C: Emission intensity from the well to which the test compound was not added

The results are shown in the following Table 4.

[0282]

[Table 4]

Example No.	SK-BR-3 cell growth inhibitory activity IC ₅₀ value (nM)	HER2ex20insYVMA cell growth inhibitory activity IC ₅₀ value (nM)
1	9.3	17
2	2.8	12
3	4.5	25
4	5.6	20
5	4.0	14
6	10	28
7	12	40
8	14	26
9	4.2	24
10	13	29
11	6.6	29
12	17	43
13	14	23
14	8.1	27
15	7.0	40
16	1.4	9.7
17	4.0	20
18	3.4	14
19	17	50
Comp. Ex. 1	> 10000	> 10000
Comp. Ex. 2	25	1900
Comp. Ex. 3	4300	3400
Comp. Ex. 4	340	900
Comp. Ex. 5	400	1300
Comp. Ex. 6	3000	4100

[0283]

From the above results, it was found that the pyrimidine compound group of the present invention has excellent cell growth inhibitory activity even against the HER2 expressing cell line (SK-BR-3) and also, against the HER2 exon 20 insertion mutant expressing cell line (Ba/F3-HER2insYVMA).

[0284]

Test Example 5 Measurement of growth inhibitory activity against HER2 expressing cell line (NCI-N87)

NCI-N87 cells as a HER2 overexpressing human stomach cancer cell line (American Type Culture Collection, Cat No. ATCC (registered trademark) CRL-5822) were suspended in an RPMI1640 medium (FUJIFILM Wako Pure Chemical Cooperation) supplemented with 10% fetal bovine serum. Subsequently, the cell suspension was seeded in each well of a 96-well flat-bottom microplate, and was then cultured in a 5% carbon dioxide gas-containing culture vessel at 37°C for 1 day. Thereafter, the compound of the present invention was dissolved in DMSO, and the compound was diluted to 1000 times the final concentration in DMSO. The compound in the DMSO solution was diluted with the medium used in the suspension of the cells, and the obtained solution was then added to each well of the culture plate, so that the final concentration of DMSO became 0.1%. Regarding a control well, DMSO was diluted with the medium used in the suspension of the cells, and the obtained solution was then added to each well of the culture plate, so that the final concentration of DMSO became 0.1%. After addition of a drug solution, the obtained mixture was further cultured in the 5% carbon dioxide gas-containing culture vessel at 37°C for 3 days. After completion of the culture for 3 days in the presence of the compound, the cells were counted using CellTiter-Glo 2.0 (manufactured by Promega) in accordance with the protocols recommended by Promega. The growth inhibition percentage was calculated according to the following equation. The concentration of the compound, in which the growth of the cells can be inhibited by 50%, was defined as IC₅₀ (nM).

$$\text{Growth inhibitory percentage (\%)} = (C - T) / (C) \times 100$$

T: Emission intensity from the well to which the test compound was added

C: Emission intensity from the well to which the test compound was not added

The results are shown in the following Table 5.

[0285]

[Table 5]

Example No.	NCI-N87 cell growth inhibitory activity IC50 value (nM)
1	10.7
2	3.0
3	4.7
4	5.6
5	7.0
6	8.5
7	11.1
8	9.7
9	6.2
10	10.5
11	9.9
12	15.0
13	11.7
14	9.1
15	11.6
16	0.9
17	2.2
18	2.6
19	7.9

[0286]

From the above results, it was found that the pyrimidine compound of the present invention has excellent cell growth inhibitory activity even against the HER2 overexpressing cell line (NCI-N87).

[0287]

Test Example 6 Measurement of phosphorylation activity inhibitory effect (*in vitro*) on wild-type and mutant EGFR

The measurement of the *in vitro* inhibitory activity of a compound against wild-type and mutant EGFR was outsourced to Carna Biosciences, Inc. (Kinase Profiling Book, <https://www.carnabio.com/japanese/product/search.cgi?mode=profiling>).

[0288]

Specifically, first, the pyrimidine compound of the present invention was diluted

stepwise with dimethyl sulfoxide (DMSO). Subsequently, the EGFR protein, the substrate peptide (Src tide, final concentration: 1 μ M), magnesium chloride (final concentration: 5 mM), manganese chloride (final concentration: 1 mM), ATP (final concentration: near K_m of each EGFR), and the pyrimidine compound of the present invention in DMSO solution (final concentration of DMSO: 1%) were added to a buffer for the kinase reaction (20 mM HEPES (pH 7.5), 1 mM dithiothreitol, and 0.01% Triton X-100), and the obtained mixture was then incubated at room temperature for 1 hour, so that the kinase reaction was carried out. To the reaction solution, Termination Buffer was added, so as to terminate the kinase reaction. Finally, using LabChip(TM) EZ Reader II (PerkinElmer), an unphosphorylated substrate peptide (S) and a phosphorylated peptide (P) were separated and detected according to microchannel capillary electrophoresis. From the peak heights of S and P, the amount of the phosphorylation reaction was obtained, and the concentration of the compound capable of inhibiting the phosphorylation reaction by 50% was defined as an IC₅₀ value (nM). The results are shown in the following table.

As the pyrimidine compound of the present invention, the compound of Example 11 (Example compound 11) was used.

[0289]

[Table 6]

	IC ₅₀ (nmol/L)
kinases	Example compound 11
EGFR	0.47
EGFR [d746-750]	0.25
EGFR [d746-750/T790M]	6.8
EGFR [L858R]	0.36
EGFR [T790M/L858R]	6.6
EGFR [D770_N771insNPG]	0.55

[0290]

From the above results, it was found that the pyrimidine compound of the present invention has excellent inhibitory activity against wild-type and mutant EGFR.

[0291]

Test Example 7 Measurement of growth inhibitory activity against EGFR overexpressing cell line and exon 20 insertion mutant EGFR expressing cell line

Growth inhibitory activity against an EGFR overexpressing cell line and an exon 20 insertion mutant EGFR expressing cell line was evaluated using MDA-MB-468 cells

(ATCC) as an EGFR overexpressing human breast cancer cell line; NCI-H1975 cells (ATCC) as L858R and T790M mutant EGFR-positive human lung cancer cells; and MCF10A_EGFR cells, MCF10A_EGFR/V769_D770insASV cells, MCF10A_EGFR/D770_N771insSVD cells, and MCF10A_EGFR/H773_V774insNPH cells (Fukushima Medical University) which were cells obtained by introducing the EGFR gene (WT, D769_N770insASV mutant, D770_N771insSVD mutant, H773_V774insNPH mutant) into MCF10A cells as human normal mammary gland cells. [0292]

The MDA-MB-468 cells were suspended in Leibovitz's L-15 medium containing 10% inactivated fetal bovine serum. The NCI-H1975 cells were suspended in RPMI-1640 medium containing 10% inactivated fetal bovine serum. The MCF10A_EGFR cells, the MCF10A_EGFR/V769_D770insASV cells, the MCF10A_EGFR/D770_N771insSVD cells, or the MCF10A_EGFR/H773_V774insNPH cells were suspended in DMEM/Ham's F-12 medium (containing L-glutamine, phenol red, HEPES, and sodium pyruvate) containing 10 µg/mL insulin, 500 ng/mL hydrocortisone, 5 µmol/L forskolin, and 5% inactivated horse serum in terms of their final concentrations. Each cell suspension was seeded in each well of a 96-well flat-bottom plate such that the number of cells per well was 500, and was then cultured in a carbon dioxide gas-free culture vessel for the MDA-MB-468 cells and in a 5% carbon dioxide gas-containing culture vessel for the other cells at 37°C for 1 day. The pyrimidine compound of the present invention was prepared at 1 mM in DMSO and then diluted 1/200 with a medium to prepare a 5 µM solution. Thereafter, the pyrimidine compound of the present invention in the DMSO solution was diluted with the medium used in the suspension of the cells, and the obtained solution was then added to each well so that the final concentration of the highest concentration of the test compound was 1000 nM. The obtained mixture was further cultured in a carbon dioxide gas-free culture vessel for the MDA-MB-468 cells and in the 5% carbon dioxide gas-containing culture vessel for the other cells at 37°C for 3 days. [0293]

The cells at the start of the culture (day 0) and after the culture (day 3) were counted using CellTiter-Glo(R) 2.0 Reagent (Promega Corp.) according to the protocol recommended by the manufacturer. The growth inhibition percentage was calculated according to the equation given below to determine the 50% inhibition concentration (GI50 (nM)) of the test compound. The results are shown in Table 7. As the pyrimidine compound of the present invention, the compounds of Examples 2, 11, and 12 (Example compounds 2, 11, and 12) was used.

[0294]

1) In the case of $T_{\text{day3}} \geq C_{\text{day0}}$

$$\text{Growth percentage (\%)} = (T_{\text{day3}} - C_{\text{day0}}) / (C_{\text{day3}} - C_{\text{day0}}) \times 100$$

T: Emission intensity from the well to which the test compound was added

C: Emission intensity from the well to which the test compound was not added

day0: Day on which the test compound was added

day3: Evaluation day

[0295]

2) In the case of $T_{\text{day3}} < C_{\text{day0}}$

$$\text{Growth percentage (\%)} = (T_{\text{day3}} - C_{\text{day0}}) / (C_{\text{day0}}) \times 100$$

T: Emission intensity from the well to which the test compound was added

C: Emission intensity from the well to which the test compound was not added

day0: Day on which the test compound was added

day3: Evaluation day

[0296]

[Table 7]

	Cell growth inhibitory activity GI 50 value (nM)					
	MDA-MB-468	NCI-H1975	MCF10A_EGFR cell (EGFR-WT)	MCF10A_EGFR/V769_D770insASV cell	MCF10A_EGFR/D770_N771insSVD cell	MCF10A_EGFR/H773_V774insNPH cell
Example compound 2	81	77	55	6.7	8.2	16
Example compound 11	99	87	81	7.3	10	18
Example compound 12	221	153	206	24	27	50

[0297]

From the above results, it was found that the pyrimidine compound group of the present invention also has excellent cell growth inhibitory activity against the wild-type EGFR overexpressing line MDA-MB-468 cells, the MCF10A_EGFR cells expressing the introduced wild-type EGFR gene, the L858R and T790M mutant EGFR-positive cells NCI-H1975 cells, and the exon 20 insertion mutant EGFR expressing cell lines (MCF10A_EGFR/V769_D770insASV cells, MCF10A_EGFR/D770_N771insSVD cells, and MCF10A_EGFR/H773_V774insNPH cells).

[0298]

Test Example 8 Measurement of growth inhibitory activity against exon 20 insertion mutant EGFR expressing cell line

Growth inhibitory activity against exon 20 insertion mutant EGFR was evaluated using H1975-EGFRinsSVD cells obtained by genetically modifying NCI-H1975 cells so as to express D770_N771insSVD mutant EGFR and to knock out endogenous EGFR (T790M/L858R), and LXF 2478 cells (Charles River Laboratories, Inc.) of V769_D770insASV mutant EGFR-positive human lung cancer patient-derived tumor.

[0299]

The H1975-EGFRinsSVD cells were prepared by introducing PB-CMV-MCS-EF1-RFP+Puro vector encoding D770_N771insSVD (insSVD), together with Super PiggyBacTransposase expression vector, to NCI-H1975 cells by electroporation with Amaxa(R) Cell Line Nucleofector(R) Kit R, then selecting cells using puromycin (Sigma-Aldrich Co. LLC.), then introducing thereto XTN(R) TALENs Site-Specific Nucleases (Transposagen Bio) by electroporation with Amaxa(R) Cell Line Nucleofector(R) Kit R, and selecting, by sequencing, cells in which endogenous EGFR (T790M/L858R) was knocked out.

[0300]

Upon evaluation of cell growth inhibitory effect, the cells of each line were suspended in RPMI-1640 medium. The cell suspension was seeded in each well of a 96-well flat-bottom plate such that the number of cells per well was 3,000, and was then cultured in a 5% carbon dioxide gas-containing culture vessel at 37°C for 1 day. The pyrimidine compound of the present invention obtained in Examples 1 to 15 (Example compounds 1-15) or compounds obtained in Comparative Examples 1 and 2 (Comparative Example compounds 1-2) were dissolved at 1 mM in DMSO and then added to each well using Tecan D300e digital dispenser (Tecan Trading AG) such that the final concentration of the highest concentration of the test compound was 1000 nM and the common ratio was 3. The cells were cultured in a 5% carbon dioxide gas-containing culture vessel at 37°C for 3 days. The cells at the start of the culture (day 0) and after the culture (day 3) were counted using CellTiter-Glo(R) 2.0 Reagent (Promega Corp.) according to the protocol recommended by the manufacturer. The growth inhibition percentage was calculated according to the equation given below to determine the 50% inhibition concentration (GI50 (nM)) of the test compound. The results are shown in Table 8.

[0301]

1) In the case of $T_{\text{day3}} \geq C_{\text{day0}}$

$$\text{Growth percentage (\%)} = (T_{\text{day3}} - C_{\text{day0}}) / (C_{\text{day3}} - C_{\text{day0}}) \times 100$$

T: Emission intensity from the well to which the test compound was added

C: Emission intensity from the well to which the test compound was not added

day0: Day on which the test compound was added

day3: Evaluation day

[0302]

2) In the case of $T_{\text{day3}} < C_{\text{day0}}$

$$\text{Growth percentage (\%)} = (T_{\text{day3}} - C_{\text{day0}}) / (C_{\text{day0}}) \times 100$$

T: Emission intensity from the well to which the test compound was added

C: Emission intensity from the well to which the test compound was not added

day0: Day on which the test compound was added

day3: Evaluation day

[0303]

[Table 8]

	Cell growth inhibitory activity GI 50 value (nM)	
	H1975-EGFRinsSVD cell	LXF 2478 cell
Example compound 1	44	29
Example compound 2	9.5	11
Example compound 3	77	24
Example compound 4	13	15
Example compound 5	33	24
Example compound 6	29	29
Example compound 7	33	33
Example compound 8	25	26
Example compound 9	65	34
Example compound 10	39	40
Example compound 11	17	19
Example compound 12	52	48
Example compound 13	48	46
Example compound 14	30	27
Example compound 15	101	58
Comparative Example 1	> 1000	> 1000
Comparative Example 2	> 1000	> 1000

[0304]

From the above results, it was found that the pyrimidine compound group of the present invention also has excellent cell growth inhibitory activity against the exon 20 insertion mutant EGFR expressing cell lines (H1975-EGFRinsSVD and LXF 2478).

[0305]

Test Example 9 Evaluation of oral absorbability

The pyrimidine compound of the present invention was suspended or dissolved in 0.5% HPMC aqueous solution and 0.1 N hydrochloric acid, and the obtained suspension or solution was orally administered to BALB/cA mice (CLEA Japan, Inc.) at a dose of 50 mg/kg/day. At 0.5, 1, 2, 4 and 6 hours after completion of the oral administration, blood was collected from the facial vein over time, so as to obtain plasma. The concentration of the compound in the obtained plasma was measured by LC-MS/MS, and the oral absorbability of the present compound was evaluated.

The results are shown in the following Table 9.

[0306]

[Table 9]

Example No.	AUC 0 - 6 hr ($\mu\text{M}\cdot\text{hr}$)	Example No.	AUC 0 - 6 hr ($\mu\text{M}\cdot\text{hr}$)
1	50	2	15
3	24	4	12
5	20	6	17
7	15	8	15
9	51	10	50
11	31	12	36
13	18	14	27
15	34	16	15
17	21	18	15
19	6.1	Comp. Ex. 2	1.5

[0307]

From the above results, it was found that the pyrimidine compound of the present invention was contained in a sufficient concentration in the plasma, so that the present pyrimidine compound exhibited favorable oral absorbability. In contrast, the compound of Comparative Example 2 had oral absorbability that was more than 4 times more attenuated than the compound of the present invention.

[0308]

Test Example 10 Evaluation of brain penetration properties

The pyrimidine compound of the present invention was suspended or dissolved in 0.5% HPMC aqueous solution and 0.1 N hydrochloric acid, and the obtained

suspension or solution was orally administered to BALB/cA mice (CLEA Japan, Inc.) at a dose of 50 mg/kg/day. At 0.5 hours after completion of the oral administration, blood was collected from the facial vein, and whole brain was then excised, so as to obtain plasma and brain samples. Water was added to the obtained brain sample in 3 times the volume of the brain sample, and the resultant was then homogenized using an ultrasonic homogenizer, so as to obtain a brain homogenate. The concentration of the compound in the obtained plasma and brain homogenate was measured by LC-MS/MS, and the brain penetration properties of the present compound were evaluated from the brain/plasma concentration of the compound.

The results are shown in the following Table 10.

[0309]

[Table 10]

Example No.	Compound concentration in plasma (μM)	Compound concentration in brain (μM)	Kp value (Compound concentration in brain/plasma)
1	9.1	1.4	0.15
2	6.6	1.8	0.27
3	11	1.4	0.13
4	8.3	2.8	0.34
5	15	2.2	0.15
6	7.5	1.3	0.17
7	7.9	1.1	0.14
8	9.9	3.3	0.33
9	13	2.4	0.18
10	13	2.4	0.18
11	12	2.7	0.23
12	11	3.2	0.29
13	13	2.8	0.22
14	9.9	2.1	0.21
15	8.1	1.2	0.15
16	12	4.4	0.35
17	17	6.5	0.39
18	7.7	1.6	0.22
19	4.9	0.7	0.14
Comp. Ex. 2	1.6	0.008	0.005

[0310]

From the above results, it was found that the pyrimidine compound of the present invention had a high brain/plasma compound concentration (K_p value) and thus, exhibited favorable brain penetration properties. On the other hand, the brain concentration of the compound of Comparative Example 2 was more than 80 times more attenuated than that of the compound of the present invention.

[0311]

Test Example 11 Antitumor effect confirmation test (*in vivo*) on direct brain transplantation models, into which Luciferase gene-introduced HER2 expressing cell line (NCI-N87-luc) is directly transplanted

In order to confirm the antitumor effects of a test compound on direct brain transplantation models, NCI-N87-Luc, which was obtained by introducing a Luciferase gene into NCI-N87 that was a human stomach cancer tumor cell line purchased from American Type Culture Collection, was used. The NCI-N87-Luc was added into a 10% fetal bovine serum (FBS)-containing RPMI-1640 medium (supplemented with 4.5 g/L glucose, 10 mM HEPES, and 1 mM sodium pyruvate) (FUJIFILM Wako Pure Chemical Corporation), and this cell line was then cultured in a 5% CO₂ incubator at 37°C.

The NCI-N87-Luc cells were re-suspended in PBS in a concentration of 6.25×10^7 cells/mL.

Using a mouse ear bar, a nude mouse with 6 to 7 weeks old (BALB/cAJcl-nu/nu, CLEA Japan, Inc.) was fixed in a brain stereotaxic apparatus, and the skin on the upper brain portion was disinfected with alcohol cotton and was then excised with a surgical knife.

A microdrill was used to drill a hole in the skull, and then, using a needle, a manipulator, and a syringe pump, 4 μ L of the cell suspension was transplanted into the brain at a rate of 0.8 μ L/min.

As a reference of the amount of brain tumor, approximately 3 weeks after the transplantation, Total Flux (Photon/sec) was measured in all of the survival cases, using IVIS (PerkinElmer, Inc., model: Lumina II). Based on the obtained results, 6 animals were assigned to each group, using the grouping program of MiSTAT (Ver. 2.00).

The test compound was orally administered to the mice once a day, every day, for 21 days from the following day of the grouping (Days 1 - 21).

For judgment of the presence or absence of effects, the value (Log₁₀) obtained by logarithmic transformation of the total flux on the judgment date was used. The test compound was administered to the mice at a dose of 25 mg/kg/day in Example 2 and Example 11, whereas it was administered at a dose of 50 mg/kg/day in Example 12.

A graph was prepared with the value obtained by logarithmic transformation (Log10) of the mean total flux of each group as a vertical axis, and with the number of days (Day) after the transplantation as a horizontal axis. The transition of the total flux over time in the drug administration period was observed.

As test compounds, the compounds of Example 2, Example 11, and Example 12 were used, and as a control, 0.1 N HCl and 0.5% HPMC aqueous solution were used.

[0312]

The results are shown in the following Figure 1 to Figure 6. The value obtained by logarithmic transformation (Log10) of the total flux on Day 22 in each group was analyzed by a Dunnett's test or a Student-t test. As a result, it was demonstrated that the aforementioned value of the test compound group was statistically significantly lower than the value of the control group (significance level (both sides): 5%) (Figure 1: the compound of Example 2 was used, $P = 0.0077$; Figure 2: the compound of Example 11 was used, $P = 0.0007$; and Figure 3: the compound of Example 12 was used, $P = 0.0012$). For the measurement of the body weight, an animal electronic balance was used. A body weight change percentage (BWCn) from the body weight on the n^{th} day (BWn) was calculated according to the following equation:

$$\text{BWCn (\%)} = [(\text{body weight on } n^{\text{th}} \text{ day}) - (\text{body weight on grouping day})] / [(\text{body weight on grouping day})] \times 100.$$

From the results of this test, it was found that the pyrimidine compound of the present invention has excellent antitumor effects against the HER2 overexpressing cell line (NCI-N87-luc) transplanted into the nude mice. Moreover, a body weight reduction of -20% or more was not observed in all of the mice to which the compound of Example 2 or Example 11 had been administered. Accordingly, it was found that there were no serious side effects (Figures 4-6).

[0313]

Test Example 12 Antitumor effect confirmation test (*in vivo*) on subcutaneous transplantation models, into which H1975-EGFRinsSVD cell line is transplanted

H1975-EGFRinsSVD cell line was cultured in RPMI-1640 (containing 4.5 g/L glucose, 10 mM HEPES and 1 mM sodium pyruvate) (FUJIFILM Wako Pure Chemical Corporation) medium containing 10% inactivated fetal bovine serum (FBS) in a 5% CO₂ incubator at 37°C.

[0314]

The H1975-EGFRinsSVD cells were resuspended at a concentration of 8×10^7 cells/mL in PBS. The cell suspension was subcutaneously transplanted at 8×10^6 cells/0.1 mL to the right chest of each 6 week old nude mouse (BALB/cAJcl-nu/nu, CLEA

Japan, Inc.) using a 1 mL syringe for tuberculin and a 25 G injection needle.

[0315]

When the tumor volumes of nude mice having tumor engraftment became on the order of 100 to 200 mm³, the mice were assigned to groups each involving 6 animals by random stratification such that the mean tumor volume was equal among the groups.

[0316]

The test compound used was the compounds of Examples 2, 11, and 12, and a 0.5% HPMC aqueous solution was used as a control. The compounds of Examples 2, 11 and 12 were orally administered at doses of 25 mg/kg/day, 25 mg/kg/day and 50 mg/kg/day, respectively.

[0317]

Each test compound or the control was orally administered every day for 14 days (Days 1 - 14) from the day following the grouping.

[0318]

To compare the transition of tumor growth over time by the administration of each test compound, a tumor volume (which is also referred to as "TV" below) was measured at a frequency of twice a week over time. For the measurement of the body weight, an animal electronic balance was used. A body weight change percentage is also referred to as "BWC" below. A body weight change percentage on the nth day (BWC_n) from the body weight on the nth day (BW_n) was calculated according to the equation given below. The transition of mean TV and BWC values of the individuals is shown in Figures 7 and 8.

[0319]

$$\text{BWC}_n (\%) = ((\text{body weight on } n^{\text{th}} \text{ day}) - (\text{body weight on grouping day})) / ((\text{body weight on grouping day}) \times 100$$

[0320]

When the mean TV value of the compound administration group on the final evaluation day (Day 15) was smaller than that of the control group and exhibited statistically significant difference (Dunnett's type multiple comparison test), this compound was judged as being effective ($P < 0.001$) and is indicated by the mark * in the drawing. The results are shown in Figure 7.

[0321]

As a result of conducting analysis by the Dunnett's type multiple comparison test, it was shown that the tumor volume was statistically significantly low ($P < 0.001$) for all the pyrimidine compounds of the present invention as compared with the control group. From the results of this test, it was found that the compounds of Examples 2, 11,

and 12 have excellent antitumor effects against the exon 20 insertion mutant EGFR expressing cell line (H1975-EGFRinsSVD) transplanted into the nude mouse brain. Moreover, a body weight reduction of 20% or more was not observed in all of the mice to which each compound had been administered.

[0322]

Test Example 13 Antitumor effect confirmation test (*in vivo*) on direct brain transplantation models, into which luciferase gene-introduced exon 20 insertion mutant EGFR expressing cell line (H1975-EGFRinsSVD-Luc) is directly transplanted

The antitumor effects and life-extending effects of the pyrimidine compounds of the present invention on direct brain transplantation models were evaluated using H1975-EGFRinsSVD-Luc line obtained by introducing luciferase into the human mutant EGFR-introduced cell line H1975-EGFRinsSVD.

[0323]

The H1975-EGFRinsSVD-Luc cells used were prepared by introducing pJTI(R) FAST DEST vector encoding luciferase, together with pJTI(R) PhiC31 Integrase expression vector, to NCI-H1975-EGFRinsSVD cells by electroporation with Amaxa(R) Cell Line Nucleofector(R) Kit R, followed by selection using hygromycin B (Nacalai Tesque, Inc.).

[0324]

The H1975-EGFRinsSVD-Luc cell line was cultured in RPMI-1640 (containing 4.5 g/L glucose, 10 mM HEPES and 1 mM sodium pyruvate) (FUJIFILM Wako Pure Chemical Corporation) medium containing 10% inactivated fetal bovine serum (FBS) in a 5% CO₂ incubator at 37°C.

[0325]

The H1975-EGFRinsSVD-Luc cells were resuspended at a concentration of 12.5×10^7 cells/mL in PBS.

Using a mouse ear bar, a nude mouse with 6 to 7 weeks old (BALB/cAJcl-nu/nu, CLEA Japan, Inc.) was fixed in a brain stereotaxic apparatus, and the skin on the top of the head was disinfected by the application of an Iodine-containing antiseptic solution using a sterile cotton swab and was then excised with a surgical knife.

[0326]

A microdrill was used to drill a hole in the skull, and then, using a needle, a manipulator, and a syringe pump, 2 μ L of the cell suspension was transplanted into the brain at a rate of 0.8 μ L/min.

[0327]

As a reference of the amount of brain tumor, 26 days after the transplantation,

Total Flux (Photon/sec) was measured in all of the survival cases, using IVIS (PerkinElmer, Inc., model: Lumina II). Based on the obtained results, 10 animals were assigned to each group by random stratification such that the mean total flux was equal among the groups.

[0328]

The test compound used was the compound of Example 11, and a 0.5% HPMC aqueous solution was used as a control. The compound of Example 11 was administered at a dose of 12.5 mg/kg/day or 25 mg/kg/day.

[0329]

The pyrimidine compound of the present invention or the control was orally administered once a day, every day, for 38 days (Days 27 - 64) from the following day of the grouping day.

[0330]

For judgment of the presence or absence of antitumor effects, the value (Log10) obtained by logarithmic transformation of the total flux on the antitumor effect judgment day (Day 47) after 3-week drug administration from the following day (Day 27) of the grouping day was used.

[0331]

A graph was prepared with the value obtained by the mean total flux of each group as a vertical axis, and with the number of days (Day) after the transplantation as a horizontal axis. The transition of the total flux over time in the drug administration period was observed.

For judgment of the presence or absence of life-extending effects, the number of survival days on the final life-extending effect evaluation day from after cell transplantation (Days 0 - 65) in the test compound group compared with the control group was analyzed by the Log-Rank test.

[0332]

The results are shown in Figures 9 and 10 given below. The value obtained by logarithmic transformation (Log10) of the total flux on Day 47 in each group was analyzed by the Dunnett's type multiple comparison test. As a result, it was demonstrated that the aforementioned value of the test compound group was statistically significantly lower than the value of the control group (significance level (both sides): 5%) ($P < 0.001$). From the results of this test, it was found that the the pyrimidine compound of the present invention has antitumor effects against the exon 20 insertion mutant EGFR expressing cell line (H1975-EGFRinsSVD-Luc) transplanted into the nude mouse brain.

In addition, the number of survival days on the final life-extending effect evaluation day from after cell transplantation (Days 0 - 65) in the test compound group compared with the control group was analyzed by the Log-Rank test. As a result, statistically significant life-extending effects were observed, as compared with the control group ($P < 0.05$).

[0333]

Test Example 14 Antitumor effect (*in vitro*) brought about by combined use of pyrimidine compound and other antitumor agent

[0334]

The distributor of each reagent, the distributor of a tumor cell line, the medium used, and the number of seeded cells are shown in the following tables.

[0335]

[Table 11]

Reagent	Distributor
Fetal bovine serum (FBS)	GIBCO or SIGMA-ALDRICH Co. LCC
McCoy's 5A medium	Thermo Fisher Scientific, Inc.
Dulbecco's Modified Eagle medium (DMEM)	FUJIFILM Wako Pure Chemical Corporation
RPMI-1640 medium	FUJIFILM Wako Pure Chemical Corporation
AZD8055	Cayman Chemical Company
Everolimus	Cayman Chemical Company
Dactolisib	Cayman Chemical Company
Buparlisib	Cayman Chemical Company
Taselisib	Selleck Chemicals
Palbociclib	Cayman Chemical Company
Fulvestrant	MedChemExpress
MK-2206	Sun-shine Chemical
5-Fluorouracil	FUJIFILM Wako Pure Chemical Corporation
Paclitaxel	FUJIFILM Wako Pure Chemical Corporation
Cisplatin	SIGMA-ALDRICH Co. LCC
Trifluridine (trifluorothymidine)	Yuki Gosei Kogyo Co., Ltd.
Gemcitabine	FUJIFILM Wako Pure Chemical Corporation
SN-38 (active metabolite of	Tokyo Chemical Industry Co., Ltd.

irinotecan)	
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[0336]

[Table 12]

Tumor cell line (origin)	Distributor of cell line	Medium	The number of seeded cells per well
BT-474 (human breast cancer)	ATCC	Dulbecco's Modified Eagle medium containing 10% FBS	250
SK-BR-3 (human breast cancer)	Sumitomo Dainippon Pharma Co., Ltd. (formerly Dainippon Pharmaceutical Co., Ltd.)	McCoy's 5A medium containing 10% FBS	125
HCC827 (human lung cancer)	ATCC	RPMI-1640 medium containing 10%FBS	250

[0337]

HER2-positive human breast cancer-derived SK-BR-3 cells [Sumitomo Dainippon Pharma Co., Ltd. (formerly Dainippon Pharmaceutical Co., Ltd.)] were suspended in McCoy's 5A medium containing 10% inactivated fetal bovine serum. Likewise, HER2-positive human breast cancer-derived BT-474 cells [American Type Culture Collection (ATCC)] were suspended in Dulbecco's Modified Eagle medium containing 10% inactivated fetal bovine serum. Exon 19 mutation (del E746-A750)-positive human lung cancer-derived HCC827 cells (ATCC) were suspended in RPMI-1640 medium containing 10% inactivated fetal bovine serum. Each cell suspension was seeded at 25 μ L/well in a 384-well flat-bottom culture plate. The plate with the seeded cells was incubated in a 5% carbon dioxide gas-containing culture vessel at 37°C.

[0338]

On the following day of the seeding, drug solutions of the compound of Example 11 and other antitumor agent mixed in combinations of varying concentrations were added to the cells.

[0339]

On the following day of the seeding, the pyrimidine compound of the present invention and the other antitumor agent were dissolved in DMSO and then added

according to the final concentrations of the maximum concentrations and the common ratios shown in Table 13. Specifically, 8 concentrations (including 0 nM) of the compound of Example 11 as the pyrimidine compound of the present invention, and 10 concentrations (including 0 nM) of the other antitumor agent were set to 80 in total of all possible combinations and added using Tecan D300e digital dispenser (Tecan Trading AG), and the plate was incubated in a 5% carbon dioxide gas-containing culture vessel at 37°C for 3 days.

[0340]

Three days later, CellTiter-Glo(TM) 2.0 Reagent (Promega Corporation) was added at 25 μ L/well, and chemiluminescence was measured using a plate reader (EnSpire(R) Multimode Plate Reader, PerkinElmer Japan Co., Ltd.).

[0341]

[Table 13]

Other antitumor agent	Tumor cell line	Other antitumor agent		Example 11	
		Maximum concentration (nM)	Common ratio	Maximum concentration (nM)	Common ratio
Gemcitabine	BT-474	30000	3	100	3
	SK-BR-3	30000	3	100	3
	HCC827	30000	3	100	3
Paclitaxel	BT-474	1000	3	100	3
	SK-BR-3	1000	3	100	3
	HCC827	100	3	100	3
5-Fluorouracil	BT-474	1000000	3	100	3
	SK-BR-3	1000000	3	100	3
Trifluridine	BT-474	1000000	3	100	3
	SK-BR-3	1000000	3	100	3
	HCC827	1000000	3	100	3
Buparlisib	BT-474	30000	3	100	3
	SK-BR-3	30000	3	100	3
	HCC827	30000	3	100	3
Taselisib	BT-474	100	3	100	3
	SK-BR-3	100	3	100	3
	HCC827	100	3	100	3
Dactolisib	BT-474	300	3	100	3

	SK-BR-3	300	3	100	3
Everolimus	BT-474	30000	3	100	3
	SK-BR-3	30000	3	100	3
	HCC827	30000	3	100	3
AZD8055	BT-474	1000	3	100	3
	SK-BR-3	1000	3	100	3
	HCC827	1000	3	100	3
MK-2206	BT-474	10000	3	100	3
	SK-BR-3	10000	3	100	3
	HCC827	10000	3	100	3
Palbociclib	BT-474	20000	3	100	3
	SK-BR-3	20000	3	100	3
	HCC827	20000	3	100	3
Fulvestrant	BT-474	100000	3	100	3
	SK-BR-3	100000	3	100	3
	HCC827	100000	3	100	3
Cisplatin	HCC827	10000	3	100	3
SN-38	HCC827	100	3	100	3

[0342]

The potentiation of an effect by combined use of the drugs was evaluated in accordance with the Chou-Talalay method (Adv. Enzyme Regul. 22: 27-55, 1984).

[0343]

A mean from 4 wells of each combination was calculated from the obtained data, and a cell survival rate normalized against a control supplemented with a medium containing a vehicle was calculated. The cell survival rate was subtracted from 1 to calculate a Fa (fraction of affect) value. A combination index (CI) was calculated by applying the Median Effect equation to the experimental data.

[0344]

It is considered that the combinations of the concentrations of the drugs for calculating CI fall within a concentration range in which the effect of one of the drugs is too strong if the Fa value is close to 1, and fall within a concentration range in which the effect of any of the drugs is too weak if the Fa value is close to 0. Such combinations are not appropriate for discussing a synergistic effect. Accordingly, combinations were extracted which attained $0.2 \leq Fa \leq 0.8$ from the Fa values calculated with the

combinations of the respective concentrations of the compound of Example 11 and the other antitumor agent.

A combinatorial effect was judged as shown in the following table (Pharmacol Rev., 58 (3), 621-81, 2006).

[0345]

[Table 14]

Range of CI (upper limit)	Description
0.1	Very strong synergistic effect
0.3	Strong synergistic effect
0.7	Synergistic effect
0.85	Moderate synergistic effect
0.9	Slight synergistic effect
1.0	Almost additive
1.2	Slight antagonistic effect
1.45	Moderate antagonistic effect
3.3	Antagonistic effect
10	Strong antagonistic effect
> 10	Very strong antagonistic effect

The results are shown in the tables given below.

In the tables, the "combined use ratio" represents a molar ratio of the other antitumor agent with the compound of Example 11 defined as 1.

[0346]

Combined use of compound of Example 11 and gemcitabine

[0347]

[Table 15]

Cell line:	BT-474			
Combined use ratio	Gemcitabine (nM)	Example 11 (nM)	Fa	CI
8100	30000	3.70	0.331	0.890
2700	30000	11.1	0.497	0.844
900	3333	3.70	0.279	0.726
900	10000	11.1	0.476	0.784

300	3333	11.1	0.454	0.821
100	1111	11.1	0.444	0.843
1.2	13.7	11.1	0.446	0.828
0.412	4.57	11.1	0.468	0.740
0.137	4.57	33.3	0.671	0.796

[0348]

[Table 16]

Cell line:	SK-BR-3			
Combined use ratio	Gemcitabine (nM)	Example 11 (nM)	Fa	CI
218700	30000	0.137	0.546	0.514
72900	10000	0.137	0.485	0.633
24300	3333	0.137	0.542	0.065
24300	10000	0.412	0.478	0.740
8100	1111	0.137	0.463	0.117
8100	3333	0.412	0.488	0.208
8100	30000	3.70	0.529	0.824
2700	370	0.137	0.473	0.035
2700	1111	0.412	0.438	0.211
2700	3333	1.23	0.456	0.444
2700	10000	3.70	0.513	0.459
2700	30000	11.1	0.555	0.674
900	123	0.137	0.440	0.027
900	370	0.412	0.503	0.029
900	1111	1.23	0.411	0.421
900	3333	3.70	0.431	0.865
900	10000	11.1	0.596	0.248
900	30000	33.3	0.695	0.294
300	41.2	0.137	0.386	0.032
300	123	0.412	0.475	0.026
300	370	1.23	0.442	0.117
300	1111	3.70	0.471	0.242
300	3333	11.1	0.515	0.438

300	10000	33.3	0.641	0.434
100	13.7	0.137	0.366	0.023
100	41.2	0.412	0.367	0.068
100	123	1.235	0.458	0.068
100	370	3.704	0.484	0.159
100	1111	11.1	0.532	0.320
100	3333	33.3	0.612	0.524
100	10000	100	0.796	0.338
33.3	13.7	0.412	0.314	0.091
33.3	41.2	1.23	0.455	0.060
33.3	123	3.70	0.505	0.122
33.3	370	11.1	0.522	0.326
33.3	1111	33.3	0.666	0.345
33.3	3333	100	0.772	0.426
11.1	13.7	1.23	0.327	0.165
11.1	41.2	3.70	0.445	0.182
11.1	123	11.1	0.479	0.429
11.1	370	33.3	0.650	0.388
11.1	1111	100.0	0.795	0.341
3.70	4.57	1.23	0.232	0.422
3.70	13.7	3.70	0.294	0.592
3.70	41.2	11.11	0.498	0.372
3.70	123	33.33	0.653	0.381
3.70	370	100.00	0.745	0.545
1.23	4.57	3.70	0.245	0.886
1.23	13.7	11.11	0.427	0.598
1.23	41.2	33.33	0.595	0.574
1.23	123	100.00	0.757	0.490
0.412	4.57	11.11	0.377	0.849
0.412	13.7	33.33	0.604	0.539
0.412	41.2	100.00	0.749	0.527
0.137	4.57	33.33	0.564	0.712
0.137	13.7	100.00	0.738	0.582

0.0457	4.57	100.00	0.748	0.532
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[0349]

[Table 17]

Cell line:	HCC827			
Combined use ratio	Gemcitabine (nM)	Example 11 (nM)	Fa	CI
24300	3333	0.137	0.519	0.018
8100	1111	0.137	0.474	0.030
2700	370	0.137	0.379	0.313
2700	1111	0.412	0.468	0.047
2700	3333	1.23	0.420	0.618
2700	10000	3.70	0.522	0.150
900	123	0.137	0.377	0.117
900	370	0.412	0.371	0.441
900	1111	1.23	0.471	0.075
900	3333	3.70	0.529	0.119
900	10000	11.1	0.551	0.310
900	30000	33.3	0.680	0.459
300	123	0.412	0.353	0.323
300	370	1.23	0.456	0.068
300	1111	3.70	0.536	0.109
300	3333	11.1	0.527	0.345
300	10000	33.3	0.673	0.478
100	123	1.23	0.336	0.676
100	370	3.70	0.526	0.113
100	1111	11.1	0.684	0.150
100	3333	33.3	0.719	0.368
33.3	123	3.70	0.387	0.297
33.3	370	11.1	0.598	0.236
33.3	1111	33.3	0.738	0.326
11.1	123	11.1	0.368	0.891
11.1	370	33.3	0.700	0.409
11.1	1111	100	0.783	0.723

3.70	123	33.3	0.695	0.422
3.70	370	100	0.760	0.849

[0350]

Combined use of compound of Example 11 and paclitaxel

[0351]

[Table 18]

Cell line:	BT-474			
Combined use ratio	Paclitaxcel (nM)	Example 11 (nM)	Fa	CI
810	111	0.137	0.692	0.619
270	37.0	0.137	0.702	0.186
270	111	0.412	0.695	0.605
90	12.3	0.137	0.580	0.235
90	37.0	0.412	0.738	0.132
90	111	1.23	0.711	0.542
30	12.3	0.412	0.637	0.150
30	37.0	1.23	0.703	0.235
30	111	3.70	0.685	0.845
10	12.3	1.23	0.652	0.176
10	37.0	3.70	0.713	0.316
3.33	4.12	1.23	0.419	0.563
3.33	12.3	3.70	0.694	0.238
1.11	4.12	3.70	0.599	0.331
1.11	12.3	11.1	0.780	0.344
0.370	1.37	3.70	0.449	0.604
0.370	4.12	11.1	0.752	0.392
0.123	0.152	1.23	0.240	0.574
0.123	0.457	3.70	0.469	0.495
0.123	1.37	11.1	0.662	0.616
0.0412	0.152	3.70	0.458	0.502
0.0412	0.457	11.1	0.669	0.587
0.0137	0.152	11.1	0.678	0.561

[0352]

[Table 19]

Cell line:	SK-BR-3			
Combined use ratio	Paclitaxcel (nM)	Example 11 (nM)	Fa	CI
30.0	4.12	0.137	0.452	0.671
10.0	4.12	0.412	0.497	0.525
10.0	12.3	1.23	0.778	0.208
10.0	37.0	3.70	0.769	0.677
3.33	4.12	1.23	0.442	0.847
3.33	12.3	3.70	0.761	0.312
1.11	4.12	3.70	0.526	0.713
1.11	12.3	11.1	0.787	0.427
0.370	4.12	11.1	0.681	0.605
0.123	1.37	11.1	0.567	0.888
0.041	0.457	11.1	0.630	0.619
0.0137	0.152	11.1	0.619	0.635
0.0137	0.457	33.3	0.791	0.776

[0353]

[Table 20]

Cell line:	HCC827			
Combined use ratio	Paclitaxcel (nM)	Example 11 (nM)	Fa	CI
27	11.1	0.412	0.785	0.620
9	11.1	1.23	0.787	0.614
3	0.412	0.137	0.288	0.675
3	11.1	3.70	0.779	0.664
0.333	0.0457	0.137	0.242	0.118
0.333	3.70	11.1	0.707	0.420
0.0370	1.23	33.3	0.699	0.231
0.0123	0.41	33.3	0.681	0.159
0.0123	1.23	100	0.792	0.183
0.00412	0.137	33.3	0.581	0.261

0.00412	0.412	100	0.743	0.224
0.00137	0.0152	11.1	0.277	0.737
0.00137	0.0457	33.3	0.502	0.413
0.00137	0.137	100	0.748	0.192
0.000457	0.0152	33.3	0.486	0.450
0.000457	0.0457	100	0.675	0.345
0.000152	0.0152	100	0.702	0.274

[0354]

Combined use of compound of Example 11 and 5-fluorouracil (5-FU)

[0355]

[Table 21]

Cell line:	BT-474			
Combined use ratio	5-FU (nM)	Example 11 (nM)	Fa	CI
7290000	1000000	0.137	0.650	0.602
2430000	333333	0.137	0.497	0.760
2430000	1000000	0.412	0.626	0.756
810000	111111	0.137	0.373	0.744
810000	1000000	1.23	0.635	0.725
270000	37037	0.137	0.259	0.771
270000	333333	1.23	0.501	0.800
270000	1000000	3.70	0.651	0.703
90000	333333	3.70	0.510	0.874
90000	1000000	11.1	0.727	0.505
30000	111111	3.70	0.428	0.733
30000	333333	11.1	0.629	0.600
30000	1000000	33.3	0.794	0.585
10000	37037	3.70	0.350	0.693
10000	111111	11.1	0.574	0.584
10000	333333	33.3	0.730	0.750
3333	37037	11.1	0.525	0.625
3333	111111	33.3	0.699	0.816
1111	12346	11.1	0.544	0.533

1111	37037	33.3	0.681	0.862
370	1372	3.70	0.254	0.664
370	4115	11.1	0.501	0.625
370	12346	33.3	0.671	0.891
123	1372	11.1	0.508	0.601
123	4115	33.3	0.676	0.868
41.2	457	11.1	0.498	0.625
13.7	152	11.1	0.480	0.674
13.7	457	33.3	0.676	0.866

[0356]

[Table 22]

Cell line:	SK-BR-3			
Combined use ratio	5-FU (nM)	Example 11 (nM)	Fa	CI
810000	111111	0.137	0.502	0.772
270000	37037	0.137	0.390	0.571
90000	12346	0.137	0.242	0.662
90000	37037	0.412	0.352	0.801
30000	12346	0.412	0.311	0.438
30000	37037	1.23	0.412	0.612
10000	37037	3.70	0.417	0.856
3333	4115	1.23	0.250	0.740
1111	1372	1.23	0.236	0.704
1111	37037	33.3	0.627	0.842
1111	111111	100	0.764	0.754
370	12346	33.3	0.642	0.685
370	37037	100	0.775	0.610
123	4115	33.3	0.641	0.667
123	12346	100	0.757	0.714
41.2	1372	33.3	0.617	0.796
41.2	4115	100	0.750	0.752
13.7	457	33.3	0.608	0.854
13.7	1372	100	0.759	0.684

[0357]

Combined use of compound of Example 11 and trifluridine (FTD)

[0358]

[Table 23]

Cell line:	BT-474			
Combined use ratio	FTD (nM)	Example 11 (nM)	Fa	CI
7290000	1000000	0.137	0.363	0.107
2430000	1000000	0.412	0.384	0.113
810000	1000000	1.23	0.398	0.176
270000	1000000	3.70	0.477	0.256
90000	333333	3.70	0.275	0.777
90000	1000000	11.1	0.642	0.302
30000	333333	11.1	0.530	0.534
30000	1000000	33.3	0.760	0.440
10000	111111	11.1	0.432	0.870
10000	333333	33.3	0.707	0.617
370	12346	33.3	0.661	0.805
13.7	152	11.1	0.425	0.898
13.7	457	33.3	0.642	0.893

[0359]

[Table 24]

Cell line:	SK-BR-3			
Combined use ratio	FTD (nM)	Example 11 (nM)	Fa	CI
2430000	333333	0.137	0.510	0.712
810000	111111	0.137	0.456	0.332
810000	333333	0.412	0.555	0.545
270000	37037	0.137	0.225	0.581
270000	111111	0.412	0.440	0.378
270000	333333	1.23	0.504	0.767
90000	111111	1.23	0.364	0.679

90000	333333	3.70	0.540	0.664
30000	37037	1.23	0.269	0.602
30000	111111	3.70	0.381	0.775
30000	333333	11.1	0.553	0.747
30000	1000000	33.3	0.703	0.785
10000	111111	11.1	0.459	0.736
10000	333333	33.3	0.660	0.530
3333	37037	11.1	0.405	0.781
3333	111111	33.3	0.639	0.411
3333	333333	100	0.796	0.296
1111	37037	33.3	0.624	0.383
1111	111111	100	0.769	0.313
370	12346	33.3	0.526	0.765
370	37037	100	0.739	0.387
123	4115	33.3	0.573	0.523
123	12346	100	0.726	0.427
41.2	1372	33.3	0.539	0.673
41.2	4115	100	0.701	0.537
13.7	457	33.3	0.533	0.707
13.7	1372	100	0.715	0.470
4.57	152	33.3	0.592	0.444
4.57	457	100	0.688	0.599
1.52	152	100	0.702	0.527

[0360]

[Table 25]

Cell line:	HCC827			
Combined use ratio	FTD (nM)	Example 11 (nM)	Fa	CI
7290000	1000000	0.137	0.478	0.789
2430000	333333	0.137	0.306	0.610
2430000	1000000	0.412	0.466	0.845
810000	1000000	1.23	0.469	0.864
30000	111111	3.70	0.233	0.717

30000	1000000	33.3	0.703	0.747
10000	37037	3.70	0.231	0.520
3333	37037	11.1	0.335	0.805
1111	12346	11.1	0.323	0.809
1111	37037	33.3	0.578	0.844
123	4115	33.3	0.569	0.859

[0361]

Combined use of compound of Example 11 and buparlisib (BKM120)

[0362]

[Table 26]

Cell line:	BT-474			
Combined use ratio	BKM120 (nM)	Example 11 (nM)	Fa	CI
24300	3333	0.137	0.712	0.478
24300	10000	0.412	0.789	0.861
8100	1111	0.137	0.498	0.497
8100	3333	0.412	0.741	0.409
2700	1111	0.412	0.538	0.428
2700	3333	1.23	0.760	0.387
900	370	0.412	0.238	0.760
900	1111	1.23	0.601	0.361
300	370	1.23	0.334	0.557
300	1111	3.70	0.718	0.287
100	123	1.23	0.226	0.530
100	370	3.70	0.537	0.400
33.3	123	3.70	0.428	0.464
33.3	370	11.1	0.749	0.398
11.1	41.2	3.70	0.420	0.424
11.1	123	11.1	0.696	0.465
3.70	13.7	3.70	0.426	0.398
3.70	41.2	11.1	0.697	0.451
1.23	4.57	3.70	0.380	0.463
1.23	13.7	11.1	0.666	0.505

0.412	4.57	11.1	0.687	0.464
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[0363]

[Table 27]

Cell line:	SK-BR-3			
Combined use ratio	BKM120 (nM)	Example 11 (nM)	Fa	CI
8100	1111	0.137	0.744	0.318
2700	370	0.137	0.473	0.389
2700	1111	0.412	0.737	0.341
900	370	0.412	0.368	0.671
900	1111	1.23	0.753	0.337
300	370	1.23	0.505	0.449
300	1111	3.70	0.770	0.380
100	370	3.70	0.580	0.506
33.3	41.2	1.23	0.271	0.454
33.3	123	3.70	0.358	0.897
33.3	370	11.1	0.790	0.373
11.1	41.2	3.70	0.437	0.539
11.1	123	11.1	0.720	0.472
3.70	13.7	3.70	0.396	0.602
3.70	41.2	11.1	0.629	0.685
1.23	4.57	3.70	0.317	0.838
1.23	13.7	11.1	0.627	0.676
0.412	4.57	11.1	0.637	0.642
0.412	13.7	33.3	0.799	0.837
0.137	4.57	33.3	0.798	0.838

[0364]

[Table 28]

Cell line:	HCC827			
Combined use ratio	BKM120 (nM)	Example 11 (nM)	Fa	CI
2700	30000	11.1	0.769	0.081

300	10000	33.3	0.751	0.077
100	13.7	0.137	0.538	0.089
100	1111	11.1	0.672	0.125
100	3333	33.3	0.748	0.046
33.3	13.7	0.412	0.471	0.663
33.3	1111	33.3	0.775	0.021
11.1	41.2	3.70	0.536	0.307
11.1	123	11.1	0.643	0.058
11.1	370	33.3	0.768	0.021
3.70	4.57	1.23	0.489	0.140
3.70	41.2	11.1	0.637	0.043
3.70	123	33.3	0.768	0.021
1.23	4.57	3.70	0.544	0.049
1.23	13.7	11.1	0.604	0.053
1.23	41.2	33.3	0.734	0.032
0.412	4.57	11.1	0.621	0.038
0.412	13.7	33.3	0.754	0.025
0.137	4.57	33.3	0.730	0.033
0.0457	4.57	100	0.791	0.045

[0365]

Combined use of compound of Example 11 and taselisib (GDC-0032)

[0366]

[Table 29]

Cell line:	BT-474			
Combined use ratio	GDC-0032 (nM)	Example 11 (nM)	Fa	CI
81	11.1	0.137	0.239	0.875
81	33.3	0.412	0.444	0.893
27	11.1	0.412	0.257	0.821
27	33.3	1.23	0.485	0.776
9	11.1	1.23	0.361	0.530
9	33.3	3.70	0.550	0.659
3	11.1	3.70	0.415	0.566

3	33.3	11.1	0.650	0.579
1	3.70	3.70	0.233	0.864
1	11.1	11.1	0.573	0.513
1	33.3	33.3	0.774	0.555
0.333	3.70	11.1	0.484	0.599
0.333	11.1	33.3	0.713	0.633
0.111	1.23	11.1	0.452	0.624
0.111	3.70	33.3	0.662	0.747
0.0370	0.412	11.1	0.435	0.649
0.0370	1.23	33.3	0.643	0.793
0.0123	0.137	11.1	0.390	0.779
0.0123	0.412	33.3	0.625	0.852
0.00412	0.0457	11.1	0.409	0.714
0.00412	0.137	33.3	0.643	0.780
0.00137	0.0152	11.1	0.392	0.769
0.000457	0.0152	33.3	0.618	0.872

[0367]

[Table 30]

Cell line:	SK-BR-3			
Combined use ratio	GDC-0032 (nM)	Example 11 (nM)	Fa	CI
729	100	0.137	0.505	0.239
243	33.3	0.137	0.408	0.230
243	100	0.412	0.559	0.140
81	11.1	0.137	0.277	0.373
81	33.3	0.412	0.358	0.420
81	100	1.23	0.531	0.210
27	11.1	0.412	0.376	0.135
27	33.3	1.23	0.519	0.101
27	100	3.70	0.566	0.195
9	3.70	0.412	0.291	0.155
9	11.1	1.23	0.317	0.349
9	33.33	3.70	0.460	0.277

9	100	11.1	0.680	0.130
3	11.1	3.70	0.396	0.318
3	33.3	11.1	0.574	0.245
3	100	33.3	0.759	0.159
1	11.1	11.1	0.501	0.370
1	33.3	33.3	0.664	0.340
1	100	100	0.800	0.304
0.333	3.70	11.1	0.440	0.535
0.333	11.1	33.3	0.560	0.699
0.333	33.3	100	0.752	0.481
0.111	1.23	11.1	0.392	0.729
0.111	3.70	33.3	0.632	0.415
0.111	11.1	100	0.746	0.501
0.0370	1.23	33.3	0.604	0.505
0.0370	3.70	100	0.688	0.813
0.0123	0.137	11.1	0.383	0.770
0.0123	0.412	33.3	0.652	0.357
0.0123	1.23	100	0.691	0.792
0.00412	0.137	33.3	0.555	0.709
0.00412	0.412	100	0.708	0.695
0.00137	0.046	33.3	0.578	0.607
0.00137	0.137	100	0.735	0.550
0.000457	0.0152	33.3	0.545	0.759
0.000457	0.0457	100	0.717	0.641
0.000152	0.0152	100	0.699	0.746

[0368]

[Table 31]

Cell line:	HCC827			
Combined use ratio	GDC-0032 (nM)	Example 11 (nM)	Fa	CI
243	33.3	0.137	0.448	0.733
81	11.1	0.137	0.281	0.867
27	3.70	0.137	0.294	0.265

27	11.1	0.412	0.328	0.607
27	33.3	1.235	0.456	0.726
9	100	11.1	0.719	0.404
3	11.1	3.70	0.414	0.451
1	11.1	11.1	0.383	0.871
1	33.3	33.3	0.678	0.533
0.333	3.70	11.1	0.445	0.453
0.333	11.1	33.3	0.606	0.631
0.111	1.23	11.1	0.314	0.748
0.111	3.70	33.3	0.545	0.761
0.111	11.1	100	0.761	0.774
0.0370	3.70	100	0.739	0.866
0.0123	0.412	33.3	0.528	0.778
0.00412	0.0457	11.1	0.262	0.894
0.000457	0.0152	33.3	0.593	0.582

[0369]

Combined use of compound of Example 11 and dactolisib (BEZ235)

[0370]

[Table 32]

Cell line:	BT-474			
Combined use ratio	BEZ235 (nM)	Example 11 (nM)	Fa	CI
729	100	0.137	0.531	0.821
243	33.3	0.137	0.441	0.599
243	100	0.412	0.543	0.749
81	33.3	0.412	0.434	0.652
81	100	1.23	0.530	0.869
27	33.3	1.23	0.484	0.466
27	100	3.70	0.559	0.766
9	33.3	3.70	0.482	0.589
9	100	11.1	0.607	0.728
9	300	33.3	0.776	0.627
3	33.3	11.1	0.552	0.617

3	100	33.3	0.748	0.577
1	11.1	11.1	0.522	0.543
1	33.3	33.3	0.699	0.671
0.333	3.7	11.1	0.426	0.739
0.333	11.1	33.3	0.654	0.789
0.111	1.23	11.1	0.386	0.824
0.111	3.70	33.3	0.641	0.817
0.0370	0.412	11.1	0.393	0.774
0.0370	1.23	33.3	0.633	0.839
0.0123	0.137	11.1	0.374	0.836
0.0123	0.412	33.3	0.635	0.828
0.00412	0.0457	11.1	0.403	0.734
0.00412	0.137	33.3	0.632	0.839
0.00137	0.0457	33.3	0.626	0.860

[0371]

[Table 33]

Cell line:	SK-BR-3			
Combined use ratio	BEZ235 (nM)	Example 11 (nM)	Fa	CI
729	100	0.137	0.727	0.786
243	33.3	0.137	0.646	0.443
243	100	0.412	0.725	0.801
81	11.1	0.137	0.462	0.427
81	33.3	0.412	0.653	0.428
81	100	1.235	0.785	0.511
27	3.70	0.137	0.205	0.780
27	33.3	1.23	0.641	0.473
27	100	3.70	0.777	0.557
9	3.70	0.412	0.216	0.756
9	11.1	1.23	0.352	0.883
9	33.3	3.70	0.644	0.497
9	100	11.1	0.790	0.540
3	3.70	1.23	0.289	0.528

3	11.1	3.70	0.391	0.838
3	33.3	11.1	0.675	0.493
1	11.1	11.1	0.569	0.461
1	33.3	33.3	0.753	0.433
0.333	3.70	11.1	0.487	0.486
0.333	11.1	33.3	0.620	0.688
0.111	3.70	33.3	0.634	0.528
0.111	11.1	100	0.739	0.802
0.037	0.412	11.1	0.341	0.873
0.0370	1.23	33.3	0.578	0.683
0.0123	0.412	33.3	0.623	0.512
0.00412	0.412	100	0.710	0.889
0.000457	0.0457	100	0.708	0.895

[0372]

Combined use of compound of Example 11 and everolimus (RAD001)

[0373]

[Table 34]

Cell line:	BT-474			
Combined use ratio	RAD001 (nM)	Example 11 (nM)	Fa	CI
2700	10000	3.70	0.658	0.289
900	123	0.137	0.422	0.768
900	3333	3.70	0.584	0.534
300	41.2	0.137	0.410	0.378
300	123	0.412	0.438	0.550
300	1111	3.70	0.586	0.366
300	3333	11.1	0.768	0.321
100	13.7	0.137	0.404	0.166
100	41.2	0.412	0.428	0.280
100	123	1.23	0.444	0.597
100	370	3.70	0.533	0.484
100	1111	11.1	0.736	0.394
33.3	4.57	0.137	0.402	0.074

33.3	13.7	0.412	0.419	0.163
33.3	41.2	1.23	0.447	0.314
33.3	123	3.70	0.544	0.381
33.3	370	11.1	0.717	0.440
11.1	4.57	0.412	0.439	0.083
11.1	13.7	1.23	0.460	0.206
11.1	41.2	3.70	0.520	0.414
11.1	123	11.1	0.723	0.424
3.70	4.57	1.23	0.460	0.186
3.70	13.7	3.70	0.534	0.376
3.70	41.2	11.1	0.705	0.470
1.23	4.57	3.70	0.545	0.355
1.23	13.7	11.1	0.718	0.436
0.412	4.57	11.1	0.709	0.461
0.412	13.7	33.3	0.796	0.795

[0374]

[Table 35]

Cell line:	SK-BR-3			
Combined use ratio	RAD001 (nM)	Example 11 (nM)	Fa	CI
72900	10000	0.137	0.669	0.444
24300	30000	1.23	0.795	0.039
2700	370	0.137	0.546	0.655
2700	3333	1.23	0.623	0.689
2700	10000	3.70	0.730	0.173
900	123	0.137	0.500	0.815
900	3333	3.70	0.644	0.501
300	41.2	0.137	0.533	0.117
300	123	0.412	0.550	0.224
300	370	1.23	0.579	0.330
300	1111	3.70	0.665	0.219
300	3333	11.1	0.798	0.235
100	13.7	0.137	0.462	0.276

100	41.2	0.412	0.512	0.228
100	123	1.23	0.554	0.261
100	370	3.70	0.596	0.377
100	1111	11.1	0.798	0.235
33.3	4.57	0.137	0.484	0.060
33.3	13.7	0.412	0.516	0.092
33.3	41.2	1.23	0.527	0.224
33.3	123	3.70	0.579	0.323
33.3	370	11.1	0.778	0.266
11.1	4.57	0.412	0.509	0.059
11.1	13.7	1.23	0.476	0.303
11.1	41.2	3.70	0.619	0.210
3.70	4.57	1.23	0.529	0.113
3.70	13.7	3.70	0.604	0.220
3.70	41.2	11.1	0.745	0.323
1.23	4.57	3.70	0.588	0.234
1.23	13.7	11.1	0.764	0.290
0.412	4.57	11.1	0.771	0.278

[0375]

[Table 36]

Cell line:	HCC827			
Combined use ratio	RAD001 (nM)	Example 11 (nM)	Fa	CI
24300	3333	0.137	0.217	0.619
2700	370	0.137	0.258	0.049
900	30000	33.3	0.636	0.196
300	1111	3.70	0.303	0.232
300	3333	11.1	0.329	0.554
300	10000	33.3	0.599	0.194
300	30000	100	0.771	0.126
100	370	3.70	0.270	0.252
100	3333	33.3	0.607	0.159
100	10000	100	0.686	0.253

33.3	123	3.70	0.245	0.290
33.3	370	11.1	0.395	0.242
33.3	1111	33.3	0.522	0.284
33.3	3333	100	0.720	0.180
11.1	123	11.1	0.418	0.198
11.1	370	33.3	0.588	0.172
11.1	1111	100	0.669	0.274
3.70	4.57	1.23	0.200	0.147
3.70	41.2	11.1	0.238	0.888
3.70	123	33.3	0.528	0.265
3.70	370	100	0.691	0.227
1.23	13.7	11.1	0.292	0.533
1.23	41.2	33.3	0.532	0.257
1.23	123	100	0.693	0.223
0.412	4.57	11.1	0.282	0.584
0.412	13.7	33.3	0.532	0.258
0.412	41.2	100	0.710	0.193
0.137	4.57	33.3	0.479	0.378
0.137	13.7	100	0.693	0.223
0.0457	4.57	100	0.706	0.199

[0376]

Combined use of compound of Example 11 and AZD8055

[0377]

[Table 37]

Cell line:	BT-474			
Combined use ratio	AZD8055 (nM)	Example 11 (nM)	Fa	CI
2430	333	0.137	0.599	0.678
810	111	0.137	0.480	0.515
810	333	0.412	0.569	0.844
270	37.0	0.137	0.345	0.454
270	111	0.412	0.502	0.456
270	333	1.23	0.584	0.786

90	37.0	0.412	0.269	0.858
90	111	1.23	0.503	0.484
90	333	3.70	0.578	0.889
30	37.0	1.23	0.399	0.368
30	111	3.70	0.477	0.678
30	333	11.1	0.624	0.843
10	37.0	3.70	0.365	0.616
10	111	11.1	0.599	0.529
10	333	33.3	0.744	0.728
3.33	12.3	3.70	0.251	0.694
3.33	37.0	11.1	0.514	0.549
3.33	111	33.3	0.718	0.666
1.11	12.3	11.1	0.435	0.624
1.11	37.0	33.3	0.674	0.733
0.370	4.12	11.1	0.378	0.708
0.370	12.3	33.3	0.625	0.854
0.123	1.37	11.1	0.332	0.818
0.123	4.12	33.3	0.632	0.817
0.0412	0.457	11.1	0.365	0.710
0.0412	1.37	33.3	0.610	0.884
0.0137	0.152	11.1	0.429	0.558
0.0137	0.457	33.3	0.624	0.836
0.00457	0.152	33.3	0.614	0.868

[0378]

[Table 38]

Cell line:	SK-BR-3			
Combined use ratio	AZD8055 (nM)	Example 11 (nM)	Fa	CI
810	111	0.137	0.746	0.529
270	37.0	0.137	0.603	0.379
270	111	0.412	0.765	0.469
90	12.3	0.137	0.332	0.466

90	37.0	0.412	0.564	0.457
90	111	1.23	0.772	0.448
30	12.3	0.412	0.351	0.431
30	37.0	1.23	0.626	0.341
30	111	3.70	0.752	0.512
10	12.3	1.23	0.440	0.286
10	37.0	3.70	0.636	0.328
3.33	4.12	1.23	0.381	0.148
3.33	12.3	3.70	0.438	0.319
3.33	37.0	11.1	0.690	0.253
1.11	0.457	0.412	0.224	0.090
1.11	4.12	3.70	0.217	0.875
1.11	12.3	11.1	0.531	0.233
1.11	37.0	33.3	0.793	0.137
0.370	0.152	0.412	0.211	0.082
0.370	4.12	11.1	0.358	0.443
0.370	12.35	33.3	0.653	0.145
0.123	1.37	11.1	0.286	0.769
0.123	4.12	33.3	0.608	0.117
0.041	0.457	11.1	0.276	0.817
0.0412	1.37	33.3	0.500	0.245
0.0412	4.12	100	0.746	0.067
0.0137	0.152	11.1	0.268	0.883
0.0137	0.457	33.3	0.485	0.265
0.0137	1.37	100	0.728	0.066
0.00457	0.152	33.3	0.500	0.225
0.00457	0.457	100	0.736	0.056
0.00152	0.152	100	0.720	0.066

[0379]

[Table 39]

Cell line:	HCC827			
Combined use ratio	AZD8055 (nM)	Example 11 (nM)	Fa	CI

2430	333	0.137	0.794	0.815
810	111	0.137	0.684	0.637
270	37.0	0.137	0.512	0.621
270	111	0.412	0.660	0.749
90	12.3	0.137	0.392	0.434
90	37.0	0.412	0.477	0.776
90	111	1.23	0.741	0.432
30	12.3	0.412	0.313	0.764
30	37.0	1.23	0.540	0.564
30	111	3.70	0.792	0.297
10	12.3	1.23	0.331	0.794
10	37.0	3.70	0.659	0.309
3.33	12.3	3.70	0.456	0.510
3.33	37.0	11.1	0.760	0.204
1.11	4.12	3.70	0.380	0.518
1.11	12.3	11.1	0.593	0.409
0.370	1.37	3.70	0.358	0.483
0.370	4.12	11.1	0.506	0.564
0.370	12.3	33.3	0.773	0.259
0.123	0.457	3.70	0.368	0.417
0.123	1.37	11.1	0.550	0.390
0.123	4.12	33.3	0.735	0.323
0.123	12.3	100	0.796	0.570
0.0412	0.152	3.70	0.380	0.373
0.0412	0.457	11.1	0.448	0.720
0.0412	1.37	33.3	0.675	0.491
0.0137	0.152	11.1	0.466	0.635
0.0137	0.457	33.3	0.642	0.614
0.00457	0.152	33.3	0.637	0.633

[0380]

Combined use of compound of Example 11 and MK-2206

[0381]

[Table 40]

Cell line:	BT-474			
Combined use ratio	MK-2206 (nM)	Example 11 (nM)	Fa	CI
8100	1111	0.137	0.509	0.551
2700	370	0.137	0.443	0.346
2700	1111	0.412	0.489	0.679
900	123	0.137	0.321	0.395
900	370	0.412	0.389	0.597
900	1111	1.23	0.529	0.494
900	10000	11.1	0.739	0.590
300	123	0.412	0.290	0.588
300	370	1.23	0.430	0.449
300	1111	3.70	0.550	0.483
300	3333	11.1	0.684	0.459
100	123	1.23	0.301	0.608
100	370	3.70	0.473	0.419
100	1111	11.1	0.630	0.391
100	3333	33.3	0.776	0.372
33.3	41.2	1.23	0.228	0.596
33.3	123	3.70	0.411	0.375
33.3	370	11.1	0.592	0.352
33.3	1111	33.3	0.752	0.368
11.1	41.2	3.70	0.281	0.651
11.1	123	11.1	0.567	0.341
11.1	370	33.3	0.723	0.412
3.70	41.2	11.1	0.496	0.459
3.70	123	33.3	0.699	0.462
1.23	13.7	11.1	0.476	0.489
1.23	41.2	33.3	0.701	0.449
1.23	123	100	0.793	0.730
0.412	4.57	11.1	0.460	0.523
0.412	13.7	33.3	0.674	0.521
0.137	1.52	11.1	0.453	0.539

0.137	4.57	33.3	0.663	0.555
0.137	13.7	100	0.792	0.734
0.0457	1.52	33.3	0.641	0.623
0.0457	4.57	100	0.775	0.833
0.0152	1.52	100	0.770	0.861

[0382]

[Table 41]

Cell line:	SK-BR-3			
Combined use ratio	MK-2206 (nM)	Example 11 (nM)	Fa	CI
24300	3333	0.137	0.591	0.880
8100	1111	0.137	0.550	0.524
8100	3333	0.412	0.601	0.767
2700	370	0.137	0.522	0.261
2700	1111	0.412	0.577	0.362
900	123	0.137	0.380	0.656
900	370	0.412	0.459	0.639
900	1111	1.23	0.626	0.193
900	10000	11.1	0.697	0.632
300	370	1.23	0.507	0.355
300	1111	3.70	0.596	0.337
300	3333	11.1	0.663	0.437
300	10000	33.3	0.720	0.662
100	123	1.23	0.393	0.598
100	370	3.70	0.562	0.225
100	1111	11.1	0.732	0.128
100	3333	33.3	0.730	0.392
100	10000	100	0.782	0.743
33.3	123	3.70	0.462	0.327
33.3	370	11.1	0.676	0.159
33.3	1111	33.3	0.744	0.295
33.3	3333	100	0.786	0.650
11.1	41.2	3.70	0.365	0.473

11.1	123	11.1	0.543	0.321
11.1	370	33.3	0.740	0.286
3.70	41.2	11.1	0.510	0.334
3.70	123	33.3	0.717	0.322
1.23	13.7	11.1	0.374	0.654
1.23	41.2	33.3	0.635	0.499
1.23	123	100	0.763	0.719
0.412	13.7	33.3	0.627	0.516
0.412	41.2	100	0.736	0.853
0.137	4.57	33.3	0.555	0.728
0.0457	1.52	33.3	0.544	0.765

[0383]

[Table 42]

Cell line:	HCC827			
Combined use ratio	MK-2206 (nM)	Example 11 (nM)	Fa	CI
8100	1111	0.137	0.299	0.710
8100	3333	0.412	0.389	0.847
2700	1111	0.412	0.311	0.639
900	123	0.137	0.265	0.131
900	3333	3.70	0.446	0.549
900	10000	11.1	0.593	0.420
300	370	1.23	0.298	0.334
300	1111	3.70	0.420	0.292
300	3333	11.1	0.561	0.236
100	370	3.70	0.338	0.346
100	1111	11.1	0.529	0.168
100	3333	33.3	0.769	0.040
33.3	370	11.1	0.573	0.078
33.3	1111	33.3	0.739	0.041
33.3	3333	100	0.782	0.072
11.1	123	11.1	0.507	0.124
11.1	370	33.3	0.700	0.055

11.1	1111	100	0.790	0.055
3.70	41.2	11.1	0.377	0.400
3.70	123	33.3	0.718	0.043
1.23	41.2	33.3	0.634	0.103
1.23	123	100	0.790	0.051
0.412	13.7	33.3	0.510	0.334
0.412	41.2	100	0.744	0.092
0.137	4.57	33.3	0.519	0.304
0.137	13.7	100	0.702	0.149
0.0457	1.52	33.3	0.427	0.717
0.0457	4.57	100	0.690	0.171
0.0152	1.52	100	0.611	0.381

[0384]

Combined use of compound of Example 11 and palbociclib

[0385]

[Table 43]

Cell line:	BT-474			
Combined use ratio	Palbociclib (nM)	Example 11 (nM)	Fa	CI
145800	20000	0.137	0.298	0.016
48600	20000	0.412	0.231	0.076
16200	20000	1.235	0.283	0.158
5400	20000	3.704	0.272	0.510
1800	20000	11.1	0.433	0.568
600	20000	33.3	0.664	0.458
200	6667	33.3	0.593	0.698
66.7	2222	33.3	0.563	0.827
66.7	6667	100	0.785	0.589
22.2	741	33.3	0.602	0.664
22.2	2222	100	0.752	0.759
7.41	247	33.3	0.611	0.631
2.47	82.3	33.3	0.588	0.719
2.47	247	100	0.776	0.634

0.823	27.4	33.3	0.608	0.642
0.823	82.3	100	0.777	0.627
0.274	3.05	11.1	0.363	0.852
0.274	9.14	33.3	0.582	0.744
0.274	27.4	100	0.756	0.740
0.0914	3.05	33.3	0.618	0.605
0.0914	9.14	100	0.753	0.753
0.0305	3.05	100	0.783	0.599

[0386]

[Table 44]

Cell line:	SK-BR-3			
Combined use ratio	Palbociclib (nM)	Example 11 (nM)	Fa	CI
145800	20000	0.137	0.685	0.039
48600	20000	0.412	0.679	0.046
16200	20000	1.23	0.693	0.048
5400	20000	3.70	0.710	0.065
1800	20000	11.1	0.759	0.101
600	20000	33.3	0.790	0.227
66.7	6667	100	0.742	0.888
7.41	247	33.3	0.523	0.841
2.47	27.4	11.1	0.310	0.741
2.47	82.3	33.3	0.510	0.885
0.274	9.14	33.3	0.510	0.886
0.0914	3.05	33.3	0.558	0.718

[0387]

[Table 45]

Cell line:	HCC827			
Combined use ratio	Palbociclib (nM)	Example 11 (nM)	Fa	CI
16200	2222	0.137	0.214	0.820
600	741	1.23	0.217	0.393

200	247	1.23	0.243	0.187
66.7	82.3	1.23	0.239	0.139
66.7	741	11.1	0.382	0.604
22.2	247	11.1	0.433	0.411
22.2	741	33.3	0.615	0.550
7.41	82.3	11.1	0.470	0.328
7.41	247	33.3	0.673	0.388
7.41	741	100	0.732	0.850
2.47	27.4	11.1	0.341	0.584
2.47	82.3	33.3	0.516	0.787
0.823	9.14	11.1	0.259	0.899
0.274	3.05	11.1	0.350	0.557
0.274	9.14	33.3	0.516	0.778
0.0914	3.05	33.3	0.490	0.872

[0388]

Combined use of compound of Example 11 and Fulvestrant

[0389]

[Table 46]

Cell line:	BT-474			
Combined use ratio	Fulvestrant (nM)	Example 11 (nM)	Fa	CI
729000	100000	0.137	0.283	0.654
243000	33333	0.137	0.206	0.773
81000	11111	0.137	0.205	0.281
81000	33333	0.412	0.231	0.549
81000	100000	1.23	0.293	0.699
27000	11111	0.412	0.227	0.241
27000	33333	1.23	0.232	0.677
27000	100000	3.70	0.326	0.741
9000	11111	1.23	0.268	0.261
9000	33333	3.70	0.317	0.540
9000	100000	11.1	0.496	0.618
3000	3704	1.23	0.227	0.273

3000	11111	3.70	0.273	0.587
3000	33333	11.1	0.540	0.491
3000	100000	33.3	0.690	0.765
1000	3704	3.70	0.275	0.527
1000	11111	11.1	0.531	0.503
1000	33333	33.3	0.761	0.531
333	3704	11.1	0.555	0.456
333	11111	33.3	0.787	0.459
111	1235	11.1	0.453	0.686
111	3704	33.3	0.769	0.508
37.0	412	11.1	0.458	0.673
37.0	1235	33.3	0.734	0.614
12.3	137	11.1	0.447	0.703
12.3	412	33.3	0.707	0.702
4.12	45.7	11.1	0.430	0.754
4.12	137	33.3	0.710	0.693
1.37	15.2	11.1	0.460	0.667
1.37	45.7	33.3	0.674	0.820
0.457	15.2	33.3	0.708	0.700

[0390]

[Table 47]

Cell line:	SK-BR-3			
Combined use ratio	Fulvestrant (nM)	Example 11 (nM)	Fa	CI
729000	100000	0.137	0.283	0.706
243000	33333	0.137	0.242	0.451
81000	33333	0.412	0.273	0.314
81000	100000	1.23	0.295	0.705
27000	11111	0.412	0.357	0.056
27000	100000	3.70	0.402	0.344
9000	11111	1.23	0.350	0.118
9000	33333	3.70	0.335	0.400

9000	100000	11.1	0.470	0.474
3000	11111	3.70	0.254	0.596
3000	33333	11.1	0.489	0.385
3000	100000	33.3	0.616	0.571
1000	11111	11.1	0.467	0.421
1000	33333	33.3	0.646	0.476
333	1235	3.70	0.210	0.689
333	3704	11.1	0.482	0.385
333	11111	33.3	0.690	0.364
333	33333	100	0.753	0.720
111	412	3.7	0.241	0.529
111	1235	11.1	0.406	0.574
111	3704	33.3	0.637	0.498
111	11111	100	0.746	0.756
37.0	412	11.1	0.342	0.823
37.0	1235	33.3	0.615	0.563
37.0	3704	100	0.753	0.723
12.3	137	11.1	0.343	0.817
12.3	412	33.3	0.604	0.599
12.3	1235	100	0.746	0.756
4.12	137	33.3	0.594	0.631
4.12	412	100	0.726	0.868
1.37	15.2	11.1	0.329	0.886
1.37	45.7	33.3	0.565	0.740
1.37	137	100	0.738	0.802
0.457	15.2	33.3	0.605	0.596
0.457	45.7	100	0.732	0.833
0.152	15.2	100	0.748	0.746

[0391]

[Table 48]

Cell line:	HCC827			
Combined use ratio	Fulvestrant (nM)	Example 11 (nM)	Fa	CI

243000	33333	0.137	0.248	0.754
81000	11111	0.137	0.301	0.128
27000	11111	0.412	0.299	0.162
9000	11111	1.23	0.245	0.475
9000	33333	3.7	0.460	0.181
9000	100000	11	0.474	0.484
3000	11111	3.70	0.398	0.236
3000	33333	11.1	0.420	0.600
3000	100000	33.3	0.693	0.252
1000	3704	3.70	0.240	0.774
1000	11111	11.1	0.386	0.696
1000	33333	33.3	0.682	0.269
1000	100000	100	0.797	0.299
333	3704	11.1	0.392	0.648
333	11111	33.3	0.635	0.376
333	33333	100	0.725	0.573
111	412	3.70	0.227	0.778
111	1235	11.1	0.354	0.835
111	3704	33.3	0.600	0.480
111	11111	100	0.736	0.520
37.0	412	11.1	0.394	0.627
37.0	1235	33.3	0.522	0.806
37.0	3704	100	0.715	0.616
12.3	412	33.3	0.627	0.396
12.3	1235	100	0.675	0.842
4.12	45.7	11.1	0.362	0.784
4.12	137	33.3	0.553	0.653
4.12	412	100	0.677	0.828
1.37	45.7	33.3	0.600	0.476
0.457	15.2	33.3	0.588	0.519
0.152	15.2	100	0.678	0.824

[0392]

Combined use of compound of Example 11 and cisplatin (CDDP)

[0393]

[Table 49]

Cell line:	HCC827			
Combined use ratio	CDDP (nM)	Example 11 (nM)	Fa	CI
24300	3333	0.137	0.744	0.685
8100	1111	0.137	0.576	0.775
8100	3333	0.412	0.726	0.793
2700	1111	0.412	0.589	0.714
900	370	0.412	0.393	0.865
900	1111	1.23	0.626	0.560
900	3333	3.70	0.750	0.662
300	1111	3.70	0.659	0.459
300	3333	11.1	0.785	0.496
100	370	3.70	0.466	0.593
100	1111	11.1	0.673	0.448
33.3	1111	33.3	0.762	0.270
11.1	370	33.3	0.623	0.407
3.70	41.2	11.1	0.346	0.597
3.70	123	33.3	0.616	0.296
3.70	370	100	0.763	0.288
1.23	13.7	11.1	0.368	0.436
1.23	41.2	33.3	0.589	0.302
1.23	123	100	0.767	0.236
0.412	13.7	33.3	0.534	0.409
0.412	41.2	100	0.746	0.267
0.137	4.57	33.3	0.523	0.430
0.137	13.7	100	0.716	0.335
0.0457	1.52	33.3	0.497	0.507
0.0457	4.57	100	0.696	0.388
0.0152	1.52	100	0.672	0.465

[0394]

Combined use of compound of Example 11 and SN-38

[0395]

[Table 50]

Cell line:	HCC827			
Combined use ratio	SN-38 (nM)	Example 11 (nM)	Fa	CI
81	11.1	0.137	0.562	0.441
27	3.70	0.137	0.302	0.401
27	11.1	0.412	0.501	0.556
9	3.70	0.412	0.299	0.422
9	11.1	1.23	0.496	0.582
3	3.70	1.23	0.369	0.344
3	11.1	3.70	0.517	0.579
1	3.70	3.70	0.275	0.680
1	11.1	11.1	0.588	0.528
0.333	3.70	11.1	0.401	0.606
0.333	11.1	33.3	0.686	0.496
0.111	3.70	33.3	0.546	0.641
0.0370	1.23	33.3	0.491	0.704
0.0370	3.70	100	0.748	0.530
0.0123	0.412	33.3	0.497	0.644
0.0123	1.23	100	0.664	0.809
0.00412	0.137	33.3	0.550	0.482
0.00412	0.412	100	0.674	0.743
0.00137	0.137	100	0.665	0.773
0.000457	0.0152	33.3	0.455	0.773
0.000457	0.0457	100	0.663	0.782
0.000152	0.0152	100	0.651	0.834

[0396]

Form these results, it was shown that combined use of the compound of Example 11 which is the pyrimidine compound of the present invention with the antimetabolite gemcitabine, 5-fluorouracil, or trifluridine, the platinum drug cisplatin, the alkaloid drug paclitaxel, the topoisomerase inhibitor SN-38, the estrogen receptor inhibitor fulvestrant, the PI3K/AKT/mTOR signaling pathway inhibitor AZD8055, everolimus, dactolisib,

buparlisib, taselisib, or MK-2206, or the CDK4/6 inhibitor palbociclib synergistically potentiates an antitumor effect.

[0397]

Test Example 15 Combination (*in vivo*) of pyrimidine compound and trastuzumab

Human stomach cancer-derived tumor cells 4-1ST were obtained as fragment tumor from the Central Institute for Experimental Animals. Tumor was removed approximately 1 month after subcutaneous transplantation and passage in a 6 week old male nude mouse (BALB/cAJcl-nu/nu, CLEA Japan, Inc.), and a fragment of approximately 2 mm square was prepared. A transplantation needle was filled with one fragment and subcutaneously inserted from around the right last rib of each nude mouse so as to enter the right back. The tumor was pushed out by pressing the inner syringe and thereby transplanted. For the measurement of the tumor size, electronic calipers were used. The tumor of each animal was measured by sandwiching the major axis and the minor axis between the measuring surfaces of the electronic calipers (Days 0, 5, 8, 12 and 15). A tumor volume (TV) was calculated from this major axis and minor axis. A relative tumor volume change percentage (T/C) was calculated from the calculated tumor volume. TV and T/C were calculated according to the following equations:

$$\text{Tumor Volume (TV) (mm}^3\text{)} = (\text{Major axis, mm}) \times (\text{Minor axis, mm}) \times (\text{Minor axis, mm})/2$$

$$\text{Relative tumor volume change percentage (T/C) (\%)} = (\text{Mean TV of the administration group})/(\text{Mean TV of a control group}) \times 100$$

For the measurement of the body weight, an animal electronic balance was used. A body weight change percentage on the n^{th} day (BWC_n) from the body weight on 0th day (BW₀) and the body weight on the n^{th} day (BW_n) was calculated according to the following equation:

$$\text{Body weight change percentage BWC}_n (\%) = (\text{BW}_n - \text{BW}_0)/\text{BW}_0 \times 100$$

Nude mice having TV of 50 to 300 mm³ were selected and assigned to groups each involving 6 animals by the equal number method [MiSTAT (ver. 2.1)] such that the means of TV were equal among the groups. Trastuzumab (Herceptin, Roche) was administered from the tail vein once a day on the 1st and 8th days (Days 1 and 8). The compound of Example 11 was orally administered once a day, every day, for 14 days (Days 1 - 14). Each dose was set to the dose shown in the tables given below. An untreated group was used as a control.

The presence or absence of a combinatorial effect and toxicity was judged from the tumor sizes and the body weights on the grouping day (Day 0) and the judgement day (Day 15). During the administration period, the body weight was measured every day

for calculation of the amount of the dosing solution.

The results are shown in the tables given below and Figure 11.

[0398]

[Table 51]

Group	Dose (mg/kg/day)	Treatment	Number of Mice	Number of Deaths	TV (mm ³ , mean ± SE)
Control (Non-treatment)	—	—	6	0	2041.3 ± 94.7
Example 11	6.25	Days 1-14, po	6	0	448.7 ± 79.0
Example 11	12.5	Days 1-14, po	6	0	62.0 ± 6.9
Trastuzumab	20	Days 1, 8, iv	6	0	1621.4 ± 273.5
Trastuzumab	40	Days 1, 8, iv	6	0	1518.8 ± 204.2
Example 11 + Trastuzumab	6.25 + 20	Days 1-14, po + Days 1, 8, iv	6	0	149.5 ± 62.6
Example 11 + Trastuzumab	12.5 + 20	Days 1-14, po + Days 1, 8, iv	6	0	7.4 ± 3.5
Example 11 + Trastuzumab	6.25 + 40	Days 1-14, po + Days 1, 8, iv	6	0	39.6 ± 8.6
Example 11 + Trastuzumab	12.5 + 40	Days 1-14, po + Days 1, 8, iv	6	0	17.3 ± 3.6

Group	Dunnett's test vs Control	Aspin-Welch's t-test vs Example 11, Tmab	T/C (%)	BWC (%, Mean ± SE)
Control (Non-treatment)	—	—	100.0	8.43 ± 1.38
Example 11	***	—	22.0	3.69 ± 0.75
Example 11	***	—	3.0	3.79 ± 1.07
Trastuzumab	ns	—	79.4	10.82 ± 0.90
Trastuzumab	*	—	74.4	9.22 ± 1.00
Example 11 + Trastuzumab	***	*, **	7.3	6.43 ± 1.11
Example 11 + Trastuzumab	***	***, **	0.4	3.03 ± 1.09
Example 11 + Trastuzumab	***	**, ***	1.9	5.76 ± 0.50
Example 11 + Trastuzumab	***	***, ***	0.8	4.81 ± 0.99

Abbreviations: Tmab, trastuzumab; po, per os; iv, intravenous; SE, standard error; ns, not significant; *, p < 0.05; **, p < 0.01; ***, p < 0.001

[0399]

As a result of analyzing TV on the 15th day (Day 15) of each group by the Dunnett's test (Dunnett's test vs Control), it was shown that the single administration groups of trastuzumab (except for the 20 mg/kg/day administration group) or Example 11 and the combined administration groups of the trastuzumab/Example 11 administration groups (Example 11 + Trastuzumab) had significantly lower TV than that of the control group. As a result of further conducting analysis by the Aspin-Welch's t-test, it was shown that the trastuzumab/Example 11 (Example 11 + Trastuzumab) combined administration groups had significantly lower TV than that of the single administration groups of the trastuzumab groups or Example 11. The mean body weight change percentages (BWC) of the combined administration groups on the judgement day were free from the enhancement of toxicity as compared with the single administration groups of the trastuzumab groups or the Example 11 groups.

[0400]

Test Example 16 Combination (*in vivo*) of pyrimidine compound, trastuzumab, and pertuzumab

Human stomach cancer-derived tumor cells 4-1ST were obtained as fragment tumor from the Central Institute for Experimental Animals. Tumor was removed approximately 1 month after subcutaneous transplantation and passage in a 6 week old male nude mouse (BALB/cAJcl-nu/nu, CLEA Japan, Inc.), and a fragment of approximately 2 mm square was prepared. A transplantation needle was filled with one fragment and subcutaneously inserted from around the right last rib of each nude mouse so as to enter the right back. The tumor was pushed out by pressing the inner syringe and thereby transplanted. For the measurement of the tumor size, electronic calipers were used. The tumor of each animal was measured by sandwiching the major axis and the minor axis between the measuring surfaces of the electronic calipers (Days 0, 5, 8, 12 and 15). A tumor volume (TV) was calculated from this major axis and minor axis. A relative tumor volume change percentage (T/C) was calculated from the calculated tumor volume. TV and T/C were calculated according to the following equations:

$$\text{Tumor Volume (TV) (mm}^3\text{)} = (\text{Major axis, mm}) \times (\text{Minor axis, mm}) \times (\text{Minor axis, mm})/2$$

$$\text{Relative tumor volume change percentage (T/C) (\%)} = (\text{Mean TV of the administration group})/(\text{Mean TV of a control group}) \times 100$$

For the measurement of the body weight, an animal electronic balance was used. A body weight change percentage on the n^{th} day (BWC_n) from the body weight on 0th day (BW₀) and the body weight on the n^{th} day (BW_n) was calculated according to the following equation:

$$\text{Body weight change percentage BWC}_n (\%) = (\text{BW}_n - \text{BW}_0)/\text{BW}_0 \times 100$$

Nude mice having TV of 100 to 300 mm³ were selected and assigned to groups each involving 6 animals by the equal number method [MiSTAT (ver. 2.0)] such that the means of TV were equal among the groups. Trastuzumab (T-mab, Herceptin, Roche) and pertuzumab (P-mab, Perjeta, Roche) were administered from the tail vein once a day on the 1st day (Day 1). The compound of Example 11 was orally administered once a day, every day, for 14 days (Days 1 - 14). Each dose was set to the dose shown in the tables given below. An untreated group was used as a control.

The presence or absence of a combinatorial effect and toxicity was judged from the tumor sizes and the body weights on the grouping day (Day 0) and the judgement day (Day 15). During the administration period, the body weight was measured every day for calculation of the amount of the dosing solution.

When an individual of TV = 0 was found, a complete response (hereinafter, CR) rate was also set as an evaluation item. For the judgement of CR, clinical CR (cCR) based on TV = 0 and pathological CR (pCR) based on pathological test were used. The significance of difference in CR rate of the trastuzumab/pertuzumab/Example 11 triple combined administration groups (Example 11 + T-mab/P-mab) from the corresponding Example 11 single administration groups and trastuzumab/pertuzumab combined administration group at the same doses thereas was analyzed by the Fisher's exact test.

CR rate = (The number of CR individuals in a group found to have CR)/(Total number of individuals in the group found to have CR) × 100

The results are shown in the tables given below and Figure 12.

[0401]

[Table 52]

Group	Dose (mg/kg/day)	Treatment	Number of Animals	Number of Death	TV (mm ³ , mean ± SE)	Dunnett's test vs control	Aspin-Welch's t- test vs Example 11, T-mab/P-mab
Control	—	—	6	0	1714.1 ± 175.9	—	—
Example 11	6.25	Days 1-14, po	6	0	295.9 ± 67.3	***	—
Example 11	12.5	Days 1-14, po	6	0	31.9 ± 10.7	***	—
T-mab/P-mab	10/20	Day 1, iv / Day 1, iv	6	0	52.8 ± 13.0	***	—
Example 11 + T-mab/P-mab	6.25 + 10/20	Days 1-14, po + Day 1, iv/Day 1, iv	6	0	0.0 ± 0.0	***	** , **
Example 11 + T-mab/P-mab	12.5 + 10/20	Days 1-14, po + Day 1, iv/Day 1, iv	6	0	0.0 ± 0.0	***	* , **

Group	T/C (%)	cCR (%) (number of cCR animals)	Fisher's exact test vs Example 11, T-mab/P-mab	pCR (%) (number of pCR animals)	Fisher's exact test vs Example 11, T-mab/P-mab	BWC (%, Mean ± SE)
Control	100.0	—	—	—	—	9.71 ± 2.18
Example 11	17.3	0 (0)	—	0 (0)	—	5.93 ± 0.25
Example 11	1.9	33 (2)	—	33 (2)	—	4.77 ± 1.14
T-mab/P-mab	3.1	17 (1)	—	17 (1)	—	8.70 ± 1.50
Example 11 + T-mab/P-mab	0.0	100 (6)	** , *	33 (2)	ns , ns	6.68 ± 2.11
Example 11 + T-mab/P-mab	0.0	100 (6)	ns , *	100 (6)	ns , *	5.20 ± 0.85

Abbreviations: T-mab, Trastuzumab; P-mab, Pertuzumab; po, per os; iv, intravenous; SE, standard error; cCR, clinical CR; pCR, pathological CR; ns, not significant; *, p < 0.05; **, p < 0.01; ***, p < 0.001

[0402]

As a result of analyzing TV on the 15th day (Day 15) of each group by the Dunnett's test (Dunnett's test vs Control), it was shown that the single administration groups of Example 11, the trastuzumab/pertuzumab double combined administration group (T-mab/P-mab), and the trastuzumab/pertuzumab/Example 11 triple combined administration groups (Example 11 + T-mab/P-mab) had significantly lower TV than that

of the control group. As a result of further conducting analysis by the Aspin-Welch's *t*-test, it was shown that the trastuzumab/pertuzumab/Example 11 triple combined administration groups had significantly lower TV than that of the single administration groups of Example 11, and the trastuzumab/pertuzumab double combined administration group. The mean body weight change percentages (BWC) of the trastuzumab/pertuzumab/Example 11 triple combined administration groups on the judgement day were free from the enhancement of toxicity as compared with the single administration groups of Example 11 group, and the trastuzumab/pertuzumab double combined administration group.

[0403]

Test Example 17 Combination (*in vivo*) of pyrimidine compound and trastuzumab emtansine

The experiment was conducted in the same manner as in Test Example 15 except that trastuzumab emtansine (Kadcyla, Roche) was used instead of trastuzumab and administered from the tail vein once a day on the 1st day (Day 1). Each dose was set to the dose shown in the tables given below. An untreated group was used as a control.

The results are shown in the tables given below and Figure 13.

[0404]

[Table 53]

Drug	Dose (mg/kg/day)	Treatment	Number of Animals	Number of Death	TV (mm ³ , Mean \pm SE)
Control (non-treatment)	—	—	6	0	1609.5 \pm 138.9
Example 11	6.25	Days 1-14, po	6	0	233.6 \pm 42.6
Trastuzumab emtansine	1.88	Day 1, iv	6	0	1183.2 \pm 229.0
Example 11 + Trastuzumab emtansine	6.25 + 1.88	Days 1-14, po + Day 1, iv	6	0	115.9 \pm 11.2

Drug	<i>p</i> -value (Dunnett's test) vs Control	<i>p</i> -value (Aspin-Welch's <i>t</i> -test) vs an Example 11 monotherapy	<i>p</i> -value (Aspin-Welch's <i>t</i> -test) vs a Trastuzumab emtansine monotherapy	T/C (%)	BWC (%, Mean \pm SE)
Control (non-treatment)	—	—	—	100.0	10.4 \pm 2.2
Example 11	***	—	—	14.5	4.0 \pm 0.7
Trastuzumab emtansine	*	—	—	73.5	8.2 \pm 1.1
Example 11 + Trastuzumab emtansine	***	*	**	7.2	7.4 \pm 1.1

Abbreviations: po, per os; iv, intravenous; SE, standard error; *, *p* < 0.05; **, *p* < 0.01; ***, *p* < 0.001.

[0405]

As a result of analyzing TV on the 15th day (Day 15) of each group by the Dunnett's test (Dunnett's test vs Control), it was shown that the single administration group of the trastuzumab emtansine group or the Example 11 group and the combined administration group of the trastuzumab emtansine/Example 11 group (Trastuzumab emtansine + Example 11) had significantly lower TV than that of the control group. As a result of further conducting analysis by the Aspin-Welch's t-test, it was shown that the combined administration group of the trastuzumab emtansine/Example 11 group had significantly lower TV than that of the single administration group of the trastuzumab emtansine group or the Example 11 group. The mean body weight change percentage (BWC) of the combined administration group on the judgement day was free from the enhancement of toxicity as compared with the single administration group of the trastuzumab emtansine group or the Example 11 group.

[0406]

Test Example 18 Combination (*in vivo*) of pyrimidine compound and capecitabine

A human stomach cancer cell line NCI-N87 was obtained from American Type Culture Collection (ATCC). The cell line was cultured in RPMI-1640 (containing 4.5 g/L glucose, 10 mM HEPES and 1 mM sodium pyruvate) (FUJIFILM Wako Pure Chemical Corporation) medium containing 10% fetal bovine serum (FBS) in a 5% CO₂ incubator at 37°C.

The NCI-N87 cells were resuspended at a concentration of 8×10^7 cells/mL in PBS. The cell suspension was subcutaneously transplanted at 8×10^6 cells/0.1 mL to the right chest of each 6 week old nude mouse (BALB/cAJcl-nu/nu, CLEA Japan, Inc.) using a 1 mL syringe for tuberculin and a 25 G injection needle.

For the measurement of the tumor size, electronic calipers were used. The major axis and minor axis of the tumor were measured, and TV and T/C were calculated according to the equations mentioned above.

For the measurement of the body weight, an animal electronic balance was used. A body weight change percentage on the n^{th} day (BWC_n) from the body weight on 0th day (BW₀) and the body weight on the n^{th} day (BW_n) was calculated according to the equation mentioned above.

Nude mice having TV of 100 to 300 mm³ were selected and assigned to groups each involving 6 animals by the equal number method [MiSTAT (ver. 2.0)] such that the means of TV were equal among the groups. Capecitabine (Tokyo Chemical Industry Co., Ltd.) and the compound of Example 11 were orally administered once a day, every day, for 14 days (Days 1 - 14). Each dose was set to the dose shown in the tables given below. An aqueous solution containing 0.1 N HCl and 0.5% HPMC was used as a

control.

The presence or absence of a combinatorial effect and toxicity was judged from the tumor sizes and the body weights on the grouping day (Day 0) and the judgement day (Day 15). During the administration period, the body weight was measured every day for calculation of the amount of the dosing solution.

The results are shown in the following tables and Figures 14 and 15.

[0407]

[Table 54]

Group	Dose	Schedule	Route	Number of	Number of	Tumor volume
						(mm ³)
						day 15
	(mg/kg/day)	(day)		Animals	Death	Mean ± S.E.
Control	-	1-14	p.o.	6	0	581.47 ± 44.61
Example 11	6.25	1-14	p.o.	6	0	272.43 ± 22.22
Capecitabine	359	1-14	p.o.	6	0	250.52 ± 18.71
Capecitabine	809	1-14	p.o.	6	2	224.76 ± 27.37
Example 11 + Capecitabine	6.25+359	1-14	p.o.	6	0	121.93 ± 13.68
Example 11 + Capecitabine	6.25+809	1-14	p.o.	6	0	101.34 ± 6.74

Group	P-value				T/C	BWC(%)	
	Dunnett's	Aspin-Welch's test					
		v.s. Control	v.s. Example	v.s. Cape			v.s. Cape
			11	359			809
		6.25	mg/kg/day	mg/kg/day	(%)	Mean ± S.E.	
		mg/kg/day					
Control	-	-	-	-	100	6.7 ± 1.8	
Example 11	***	-	ns	ns	47	6.3 ± 0.9	
Capecitabine	***	ns	-	ns	43	5.7 ± 1.3	
Capecitabine	***	ns	ns	-	39	3.5 ± 4.5	
Example 11 + Capecitabine	***	***	***	*	21	3.6 ± 1.3	
Example 11 + Capecitabine	***	***	***	*	17	-5.4 ± 4.9	

*: p< 0.05 **: p< 0.01 ***: p< 0.001, ns: not significant (p>0.05)

[0408]

As a result of analyzing TV on the 15th day (Day 15) of each group by the

Dunnett's test (Dunnett's test vs Control), it was shown that the single administration groups of the capecitabine groups or the Example 11 group and the combined administration groups of the Example 11/capecitabine groups (Example 11 + Capecitabine) had significantly lower TV than that of the control group. It was further shown that the combined administration groups of the Example 11/capecitabine groups had significantly lower TV than that of the single administration groups of the capecitabine groups or the Example 11 group. The mean body weight change percentages (BWC) of the combined administration groups on the judgement day were free from the enhancement of toxicity as compared with the single administration groups of the capecitabine groups or the Example 11 group.

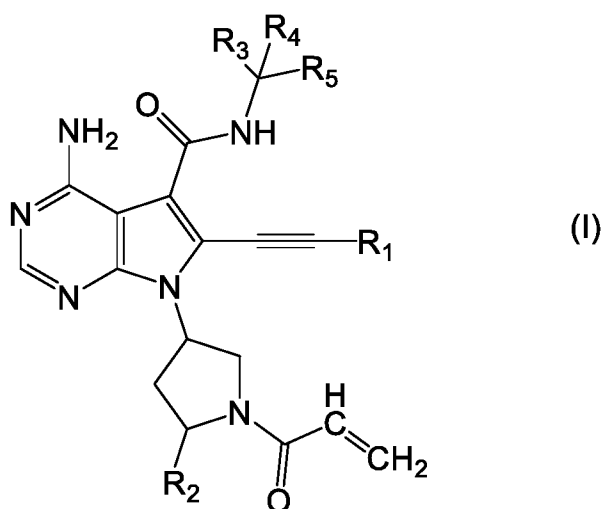
[0409]

It is to be noted that all documents and publications cited in the present description are incorporated herein by reference in their entirety, regardless of the purpose thereof. Moreover, the present description includes the contents disclosed in the claims, specification and drawings of Japanese Patent Application No. 2020-121733 (filed on July 15, 2020), from which the present application claims priority.

Several embodiments of the present invention are described above. However, these embodiments are provided for illustrative purpose only, and thus, are not intended to limit the scope of the present invention. These novel embodiments can be carried out in various other forms, and various abbreviations, substitutions and alternations can be carried out, unless they are deviated from the spirit of the invention. These embodiments and the modifications thereof are included in the scope or spirit of the invention, and are also included in the invention according to the claims and the scope equivalent thereto.

THE CLAIMS DEFINING THE INVENTION AS FOLLOWS:

1. An antitumor agent when used for combined administration with other antitumor agent, the antitumor agent comprising a pyrimidine compound represented by the following formula (I), or a salt thereof:



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

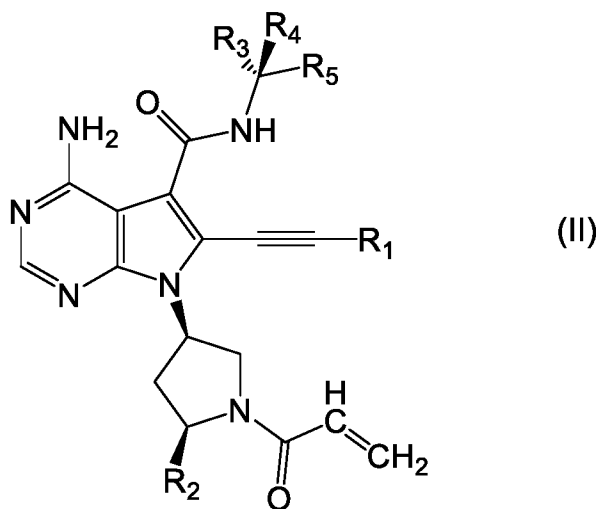
R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

2. The antitumor agent according to claim 1, wherein the pyrimidine compound is a compound represented by the following formula (II):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

3. The antitumor agent according to claim 1 or 2, wherein the pyrimidine compound is represented by the formula (I) or (II) wherein

R₁ is a methyl group, an ethyl group, an isopropyl group, a tert-butyl group, a 1-methyl-1-methoxyethyl group, or a cyclopropyl group;

R₂ is a methyl group, an ethyl group, a methoxymethyl group, or an ethoxymethyl group;

R₃ is a methyl group, an ethyl group, or a trifluoromethyl group;

R₄ is a hydrogen atom or a methyl group; and

R₅ is a phenyl group, a 2-fluorophenyl group, a 3-chlorophenyl group, a 2,3-difluorophenyl group, a 2,4-difluorophenyl group, or a 3,5-difluorophenyl group.

4. The antitumor agent according to any one of claims 1 to 3, wherein the pyrimidine compound is represented by the formula (I) or (II) wherein

R₁ is a methyl group, a tert-butyl group, or a cyclopropyl group;

R₂ is a methyl group, an ethyl group, or a methoxymethyl group;

R₃ is a methyl group;

R₄ is a hydrogen atom; and

R₅ is a phenyl group.

5. The antitumor agent according to any one of claims 1 to 4, wherein the pyrimidine compound is a compound selected from the following (1) to (3):

(1) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-N-((R)-1-phenylethyl)-6-(prop-1-yn-1-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide,

(2) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(cyclopropylethynyl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide, and

(3) 7-((3R,5S)-1-acryloyl-5-methylpyrrolidin-3-yl)-4-amino-6-(3,3-dimethylbut-1-yn-1-yl)-N-((R)-1-phenylethyl)-7H-pyrrolo[2,3-d]pyrimidine-5-carboxamide.

6. The antitumor agent according to any one of claims 1 to 5, wherein the other antitumor agent is at least one agent selected from antimetabolites, molecular targeting drugs, platinum drugs and alkaloid drugs.

7. The antitumor agent according to any one of claims 1 to 6, wherein the other antitumor agent is at least one agent selected from 5-fluorouracil (5-FU), trifluridine, gemcitabine, capecitabine, trastuzumab, pertuzumab, trastuzumab emtansine, AZD8055, everolimus, dactolisib, buparlisib, taselisib, palbociclib, fulvestrant, cisplatin and paclitaxel.

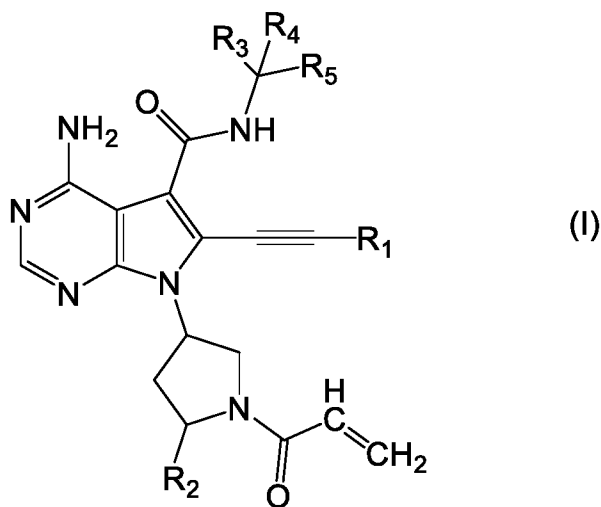
8. The antitumor agent according to any one of claims 1 to 7 for the treatment of tumor.

9. The antitumor agent according to any one of claims 1 to 8, wherein the pyrimidine compound or the salt thereof is administered to a tumor patient given the other antitumor agent or a tumor patient to be given the other antitumor agent.

10. The antitumor agent according to any one of claims 1 to 9 for oral administration.

11. A pharmaceutical composition comprising a pyrimidine compound or a salt thereof and other antitumor agent, wherein

the pyrimidine compound is a compound represented by the following formula (I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

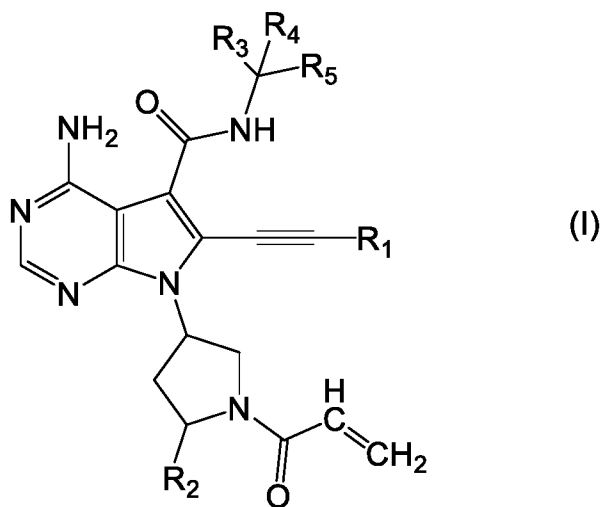
R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

12. The antitumor agent according to claim 8, wherein the pyrimidine compound or the salt thereof and the other antitumor agent are administered concurrently, sequentially, or at an interval.

13. Use of a pyrimidine compound or a salt thereof for the production of a medicament that is used in combination with other antitumor agent in the treatment of tumor, wherein the pyrimidine compound is a compound represented by the following formula (I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

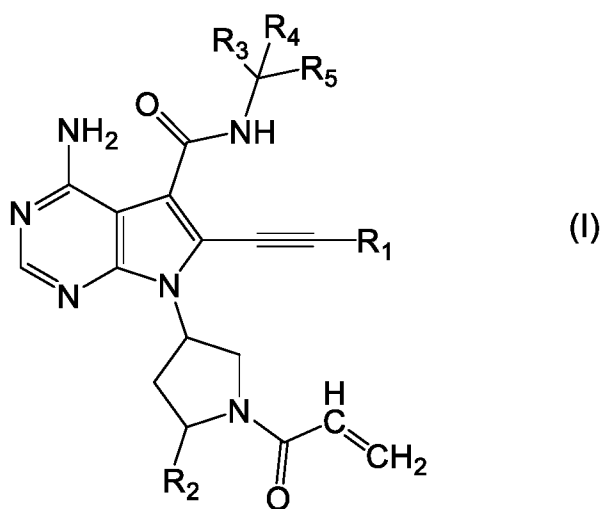
R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

14. An antitumor effect potentiator when used for potentiating the antitumor effect of other antitumor agent, the antitumor effect potentiator comprising a pyrimidine compound represented by the following formula (I), or a salt thereof:



wherein R_1 represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R_2 represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R_3 represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

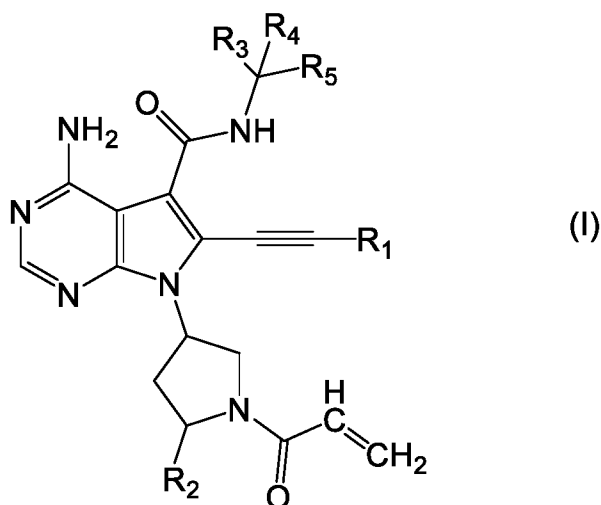
R_4 represents a hydrogen atom or a C1-C4 alkyl group; and

R_5 represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

15. A method for treating tumor, comprising administering an effective amount of an antitumor agent according to any one of claims 1 to 10 and other antitumor agent or a pharmaceutical composition according to claim 11 to a patient in need thereof.

16. A method for treating tumor by combined use with other antitumor agent, comprising administering an effective amount of a pyrimidine compound or a salt thereof to a patient in need thereof, wherein

the pyrimidine compound is a compound represented by the following formula (I):



wherein R_1 represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R_2 represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

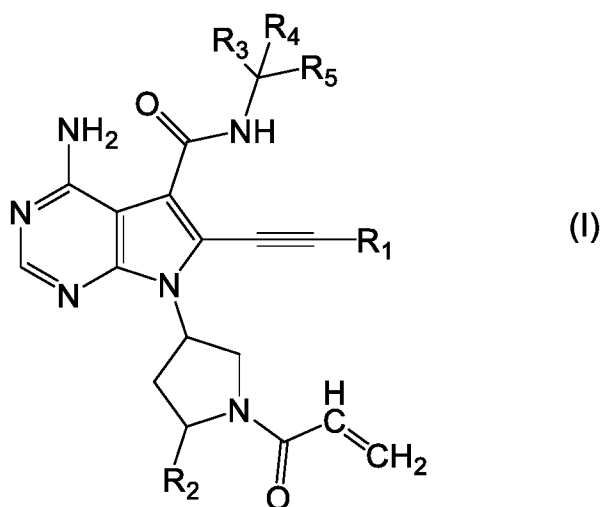
R_3 represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine

atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

17. A pyrimidine compound or a salt thereof when used for a method for treating tumor by combined use with other antitumor agent, wherein the pyrimidine compound is a compound represented by the following formula (I):



wherein R₁ represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

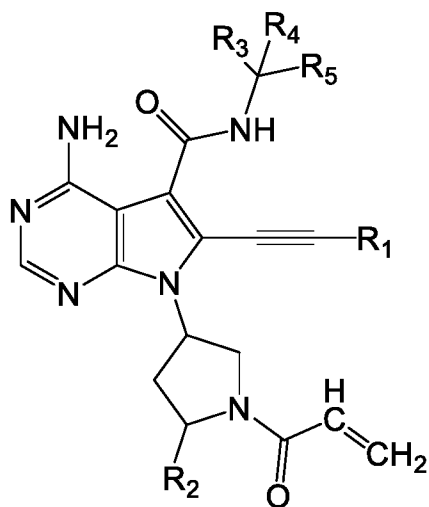
R₂ represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

R₃ represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R₄ represents a hydrogen atom or a C1-C4 alkyl group; and

R₅ represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

18. Use of a pyrimidine compound or a salt thereof for treating tumor by combined use with other antitumor agent, wherein the pyrimidine compound is a compound represented by the following formula (I):



(I)

wherein R_1 represents a C1-C4 alkyl group optionally having a C1-C4 alkoxy group as a substituent, or a C3-C4 cycloalkyl group;

R_2 represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group optionally having 1 to 5 C1-C4 alkoxy groups or fluorine atoms each as a substituent(s), or a C1-C6 alkoxy group;

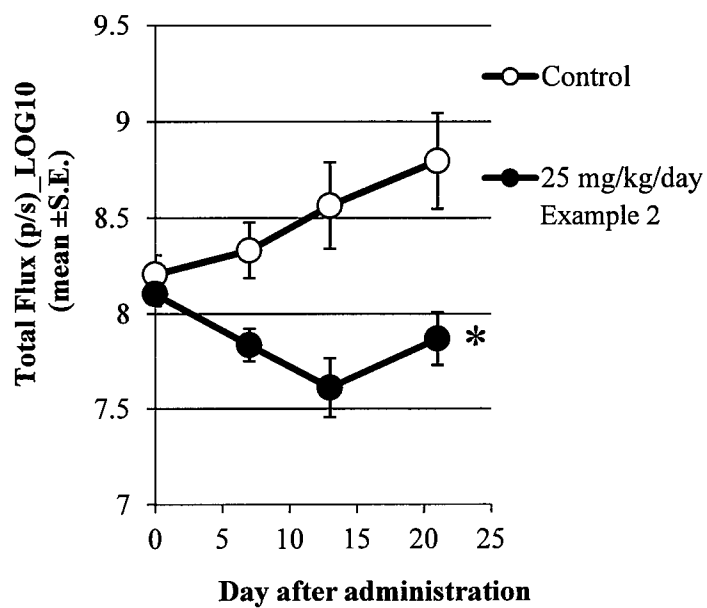
R_3 represents a hydrogen atom, or a C1-C4 alkyl group optionally having 1 to 5 fluorine atoms as a substituent(s);

R_4 represents a hydrogen atom or a C1-C4 alkyl group; and

R_5 represents a phenyl group optionally having 1 to 3 substituents selected from fluorine atoms and chlorine atoms.

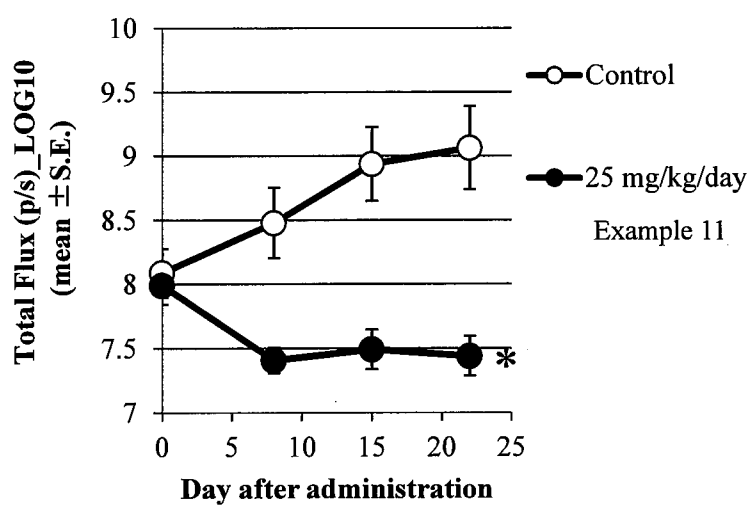
DRAWINGS

[Figure 1]



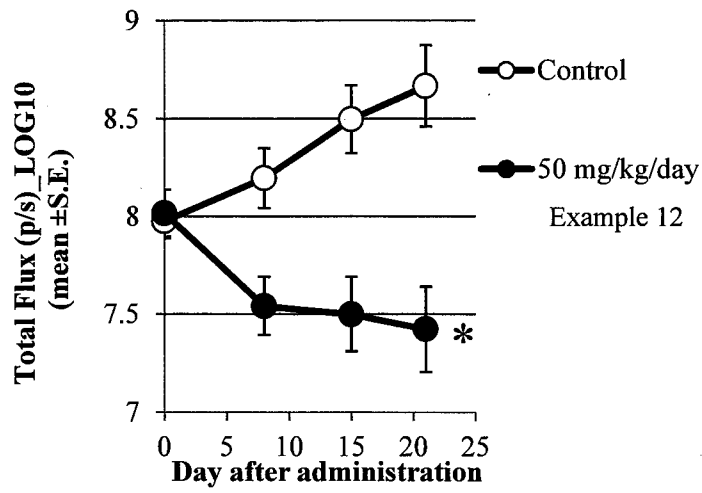
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[Figure 2]



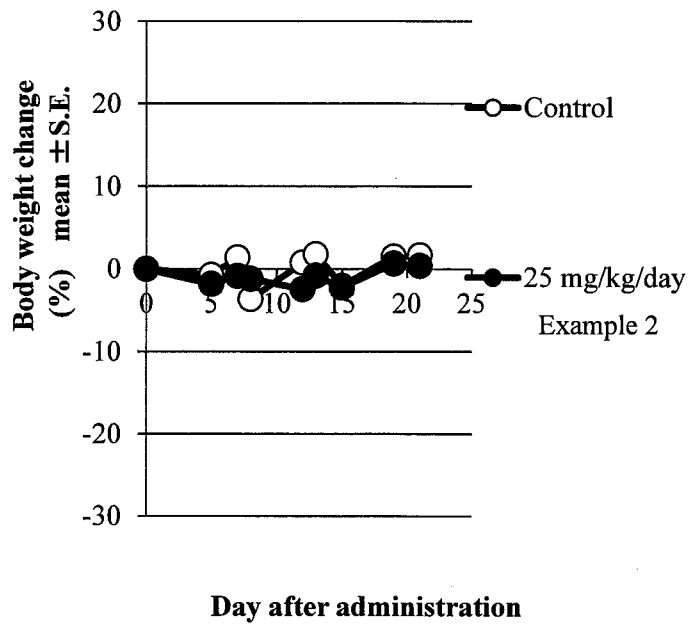
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[Figure 3]

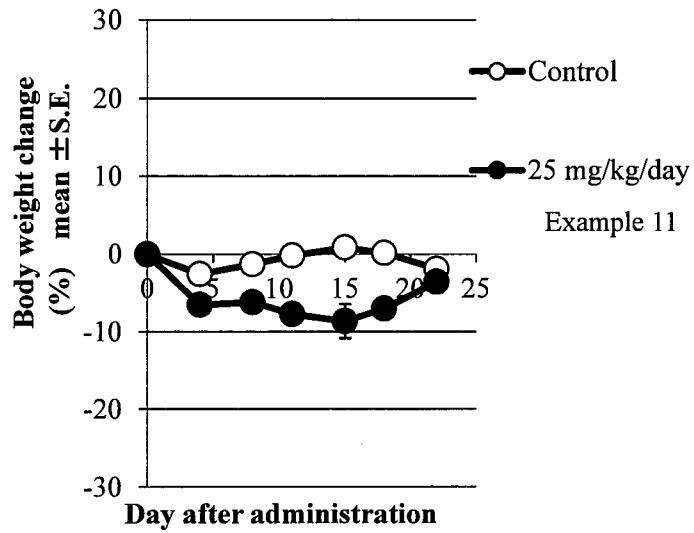


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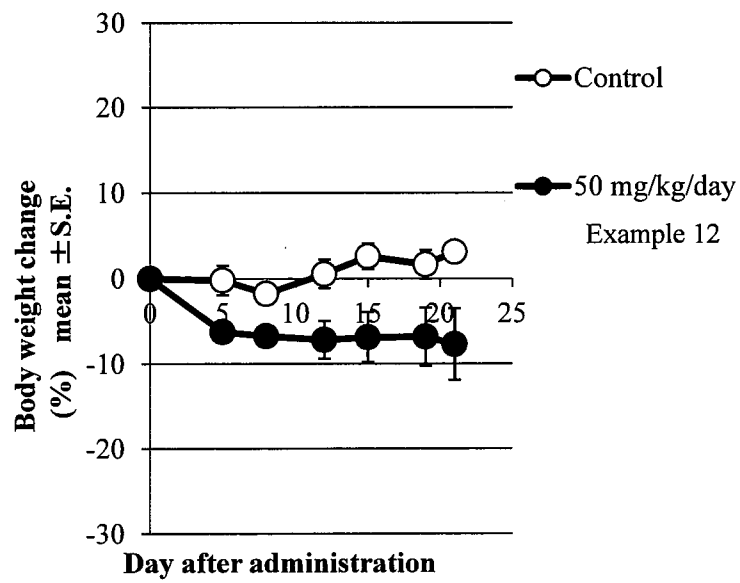
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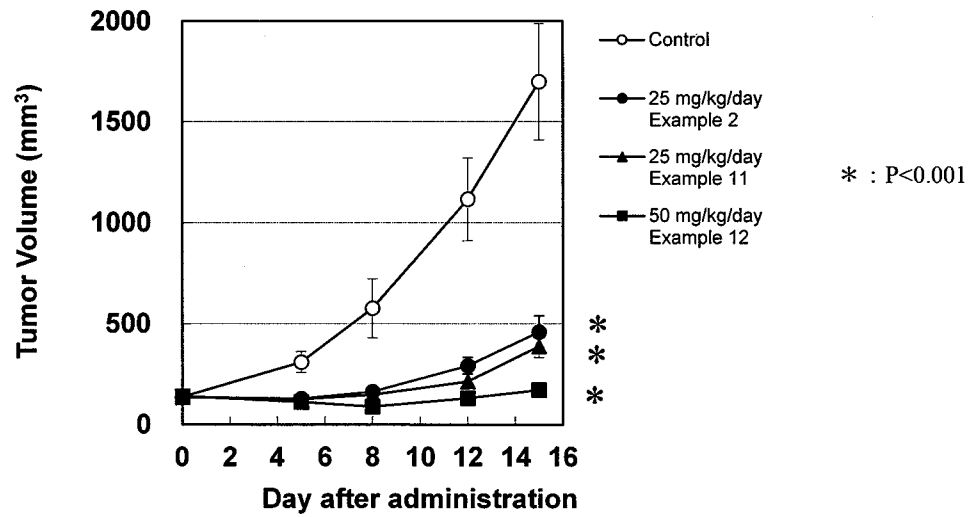
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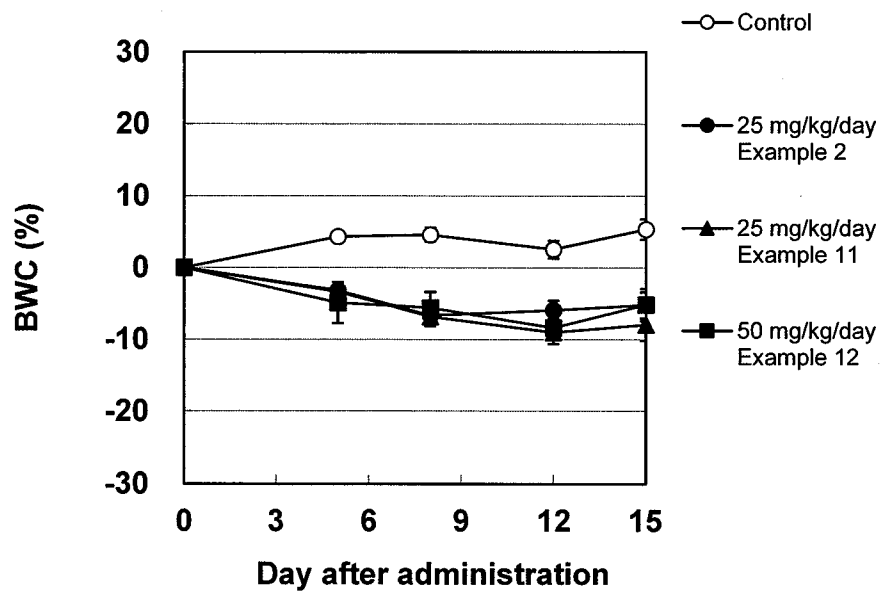
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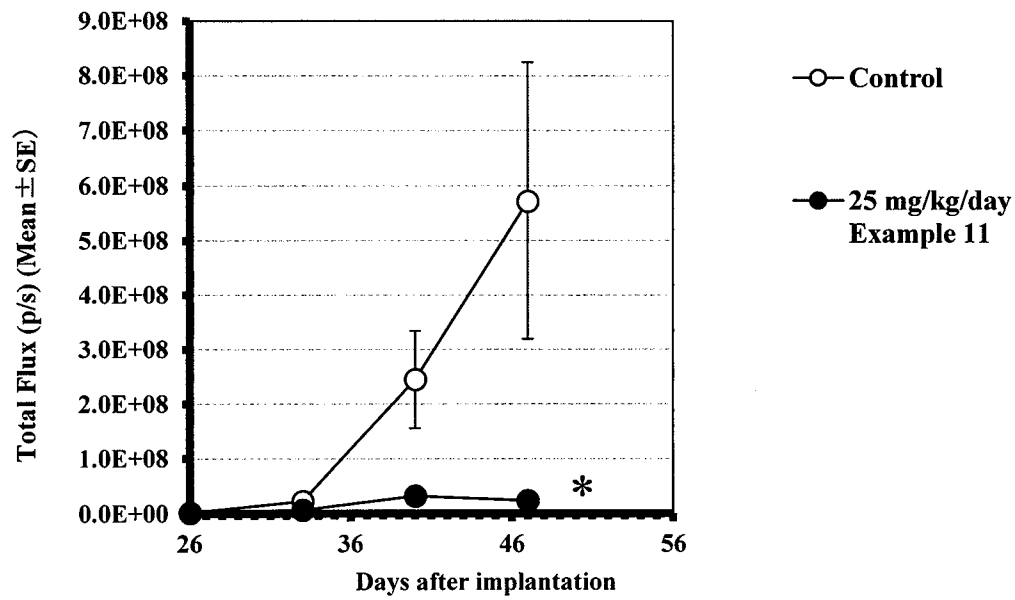
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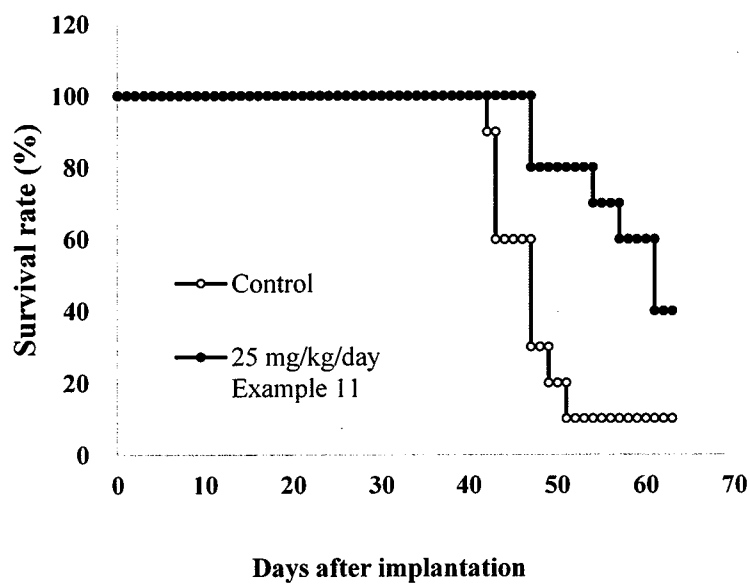
[Figure 8]



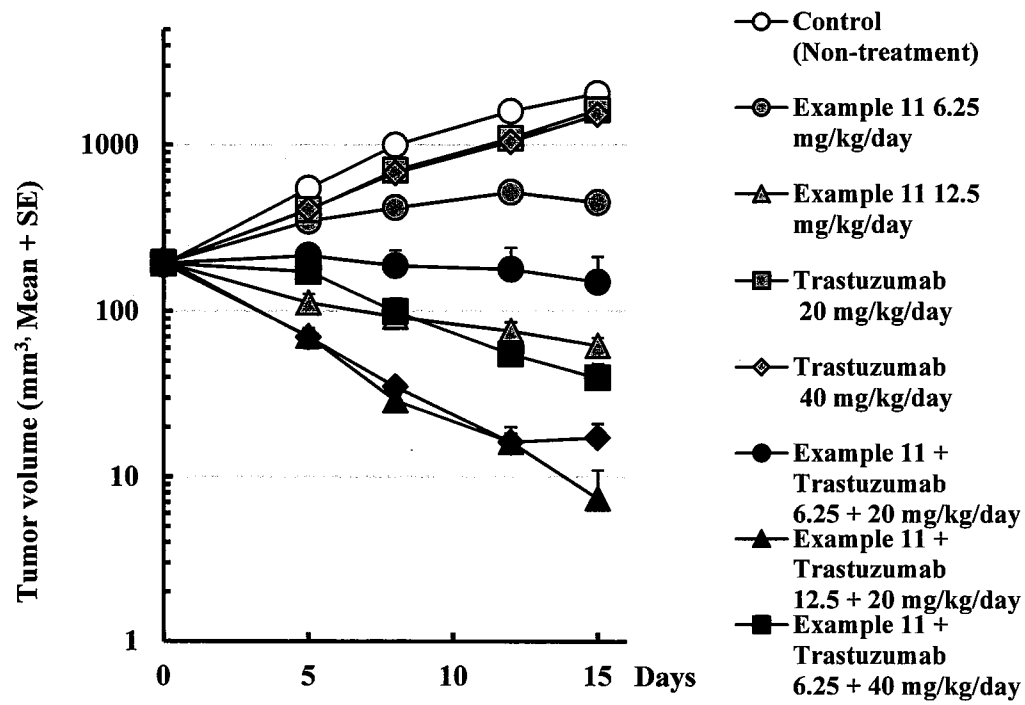
[Figure 9]



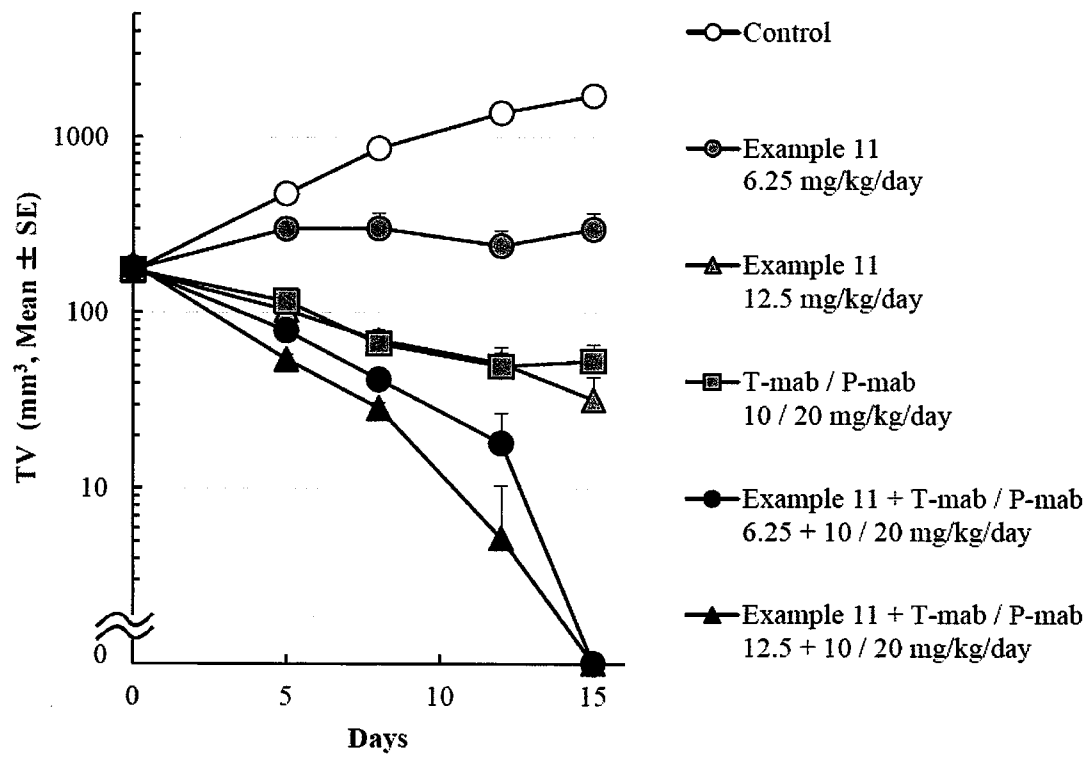
[Figure 10]



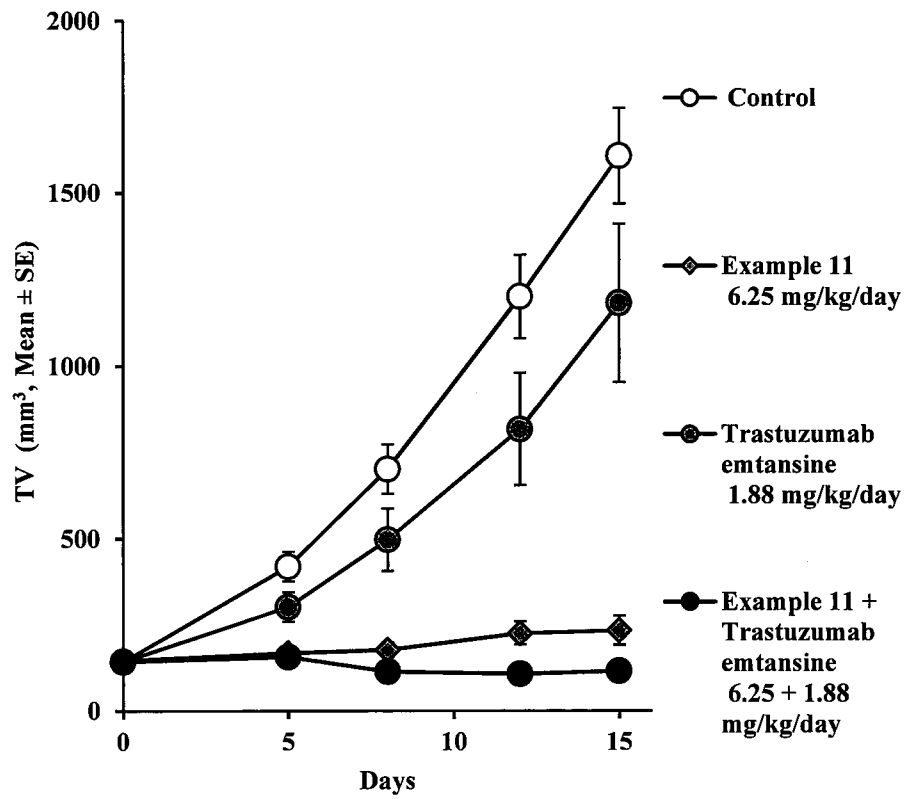
[Figure 11]



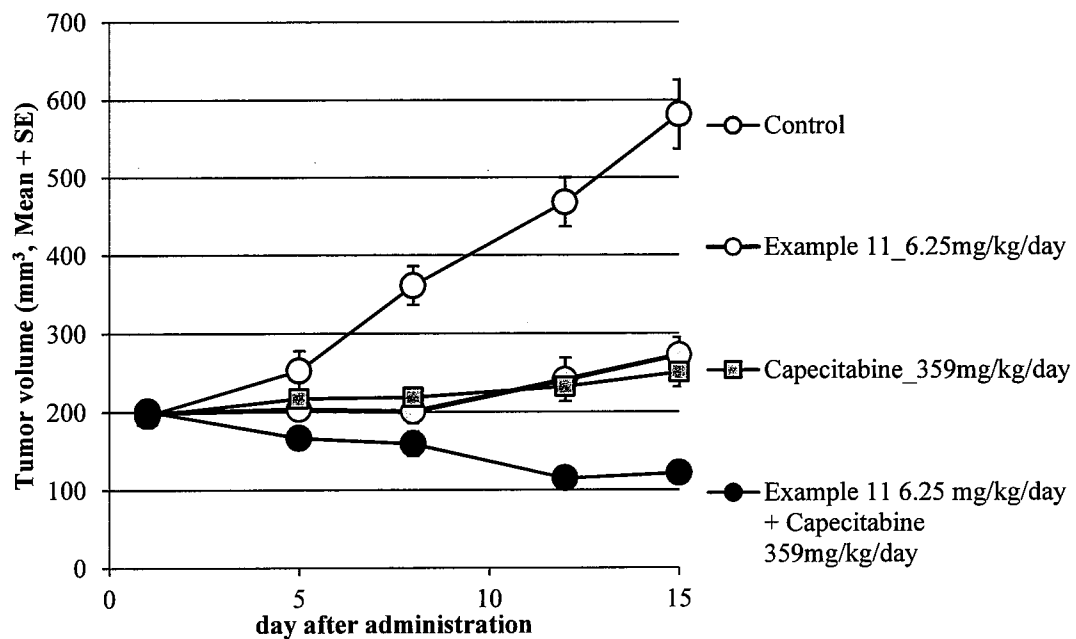
[Figure 12]



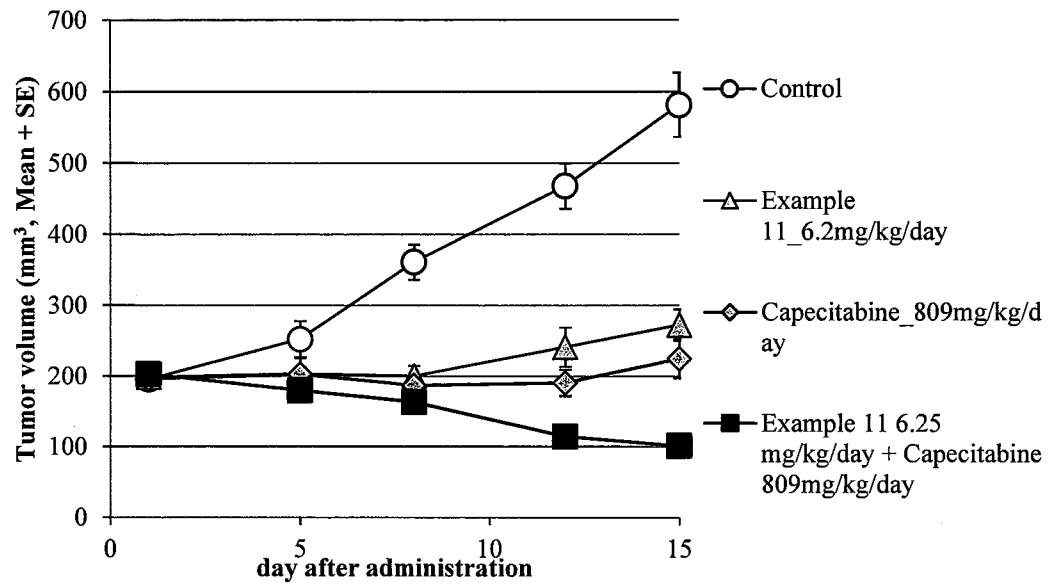
[Figure 13]



[Figure 14]



[Figure 15]



SEQUENCE LISTING

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Leu Pro Thr Asn Ala Ser Leu Ser Phe Leu Gln Asp Ile Gln Glu Val
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Gln Gly Tyr Val Leu Ile Ala His Asn Gln Val Arg Gln Val Pro Leu
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Gln Arg Leu Arg Ile Val Arg Gly Thr Gln Leu Phe Glu Asp Asn Tyr
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Leu Cys Tyr Gln Asp Thr Ile Leu Trp Lys Asp Ile Phe His Lys Asn
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His Pro Cys Ser Pro Met Cys Lys Gly Ser Arg Cys Trp Gly Glu Ser
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Ser Glu Asp Cys Gln Ser Leu Thr Arg Thr Val Cys Ala Gly Gly Cys
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Ala Arg Cys Lys Gly Pro Leu Pro Thr Asp Cys Cys His Glu Gln Cys
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Ala Ala Gly Cys Thr Gly Pro Lys His Ser Asp Cys Leu Ala Cys Leu
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His Phe Asn His Ser Gly Ile Cys Glu Leu His Cys Pro Ala Leu Val
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Thr Tyr Asn Thr Asp Thr Phe Glu Ser Met Pro Asn Pro Glu Gly Arg
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Tyr Thr Phe Gly Ala Ser Cys Val Thr Ala Cys Pro Tyr Asn Tyr Leu
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Glu Val Thr Ala Glu Asp Gly Thr Gln Arg Cys Glu Lys Cys Ser Lys
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Pro Cys Ala Arg Val Cys Tyr Gly Leu Gly Met Glu His Leu Arg Glu
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Val Arg Ala Val Thr Ser Ala Asn Ile Gln Glu Phe Ala Gly Cys Lys

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365

Lys Ile Phe Gly Ser Leu Ala Phe Leu Pro Glu Ser Phe Asp Gly Asp
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Asp Ser Leu Pro Asp Leu Ser Val Phe Gln Asn Leu Gln Val Ile Arg
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Gly Arg Ile Leu His Asn Gly Ala Tyr Ser Leu Thr Leu Gln Gly Leu
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Gly Ile Ser Trp Leu Gly Leu Arg Ser Leu Arg Glu Leu Gly Ser Gly
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Leu Ala Leu Ile His His Asn Thr His Leu Cys Phe Val His Thr Val
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Pro Trp Asp Gln Leu Phe Arg Asn Pro His Gln Ala Leu Leu His Thr
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Gln Leu Cys Ala Arg Gly His Cys Trp Gly Pro Gly Pro Thr Gln Cys
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Ser Tyr Met Pro Ile Trp Lys Phe Pro Asp Glu Glu Gly Ala Cys Gln
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Met Ser Tyr Leu Glu Asp Val Arg Leu Val His Arg Asp Leu Ala Ala
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Arg Asn Val Leu Val Lys Ser Pro Asn His Val Lys Ile Thr Asp Phe
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Arg Arg Phe Thr His Gln Ser Asp Val Trp Ser Tyr Gly Val Thr Val
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Val Gln Gly Tyr Val Leu Ile Ala His Asn Gln Val Arg Gln Val Pro
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His Gln Leu Cys Ala Arg Gly His Cys Trp Gly Pro Gly Pro Thr Gln
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Cys Phe Gly Pro Glu Ala Asp Gln Cys Val Ala Cys Ala His Tyr Lys

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575

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Leu Ser Tyr Met Pro Ile Trp Lys Phe Pro Asp Glu Glu Gly Ala Cys
595 600 605

Gln Pro Cys Pro Ile Asn Cys Thr His Ser Cys Val Asp Leu Asp Asp
610 615 620

Lys Gly Cys Pro Ala Glu Gln Arg Ala Ser Pro Leu Thr Ser Ile Ile
625 630 635 640

Ser Ala Val Val Gly Ile Leu Leu Val Val Val Leu Gly Val Val Phe
645 650 655

Gly Ile Leu Ile Lys Arg Arg Gln Gln Lys Ile Arg Lys Tyr Thr Met
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Arg Arg Leu Leu Gln Glu Thr Glu Leu Val Glu Pro Leu Thr Pro Ser
675 680 685

Gly Ala Met Pro Asn Gln Ala Gln Met Arg Ile Leu Lys Glu Thr Glu
690 695 700

Leu Arg Lys Val Lys Val Leu Gly Ser Gly Ala Phe Gly Thr Val Tyr
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Lys Gly Ile Trp Ile Pro Asp Gly Glu Asn Val Lys Ile Pro Val Ala
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Ile Lys Val Leu Arg Glu Asn Thr Ser Pro Lys Ala Asn Lys Glu Ile
740 745 750

Leu Asp Glu Ala Tyr Val Met Ala Gly Val Gly Ser Pro Tyr Val Ser
755 760 765

Arg Leu Leu Gly Ile Cys Leu Thr Ser Thr Val Gln Leu Val Thr Gln
770 775 780

Leu Met Pro Tyr Gly Cys Leu Leu Asp His Val Arg Glu Asn Arg Gly
785 790 795 800

Arg Leu Gly Ser Gln Asp Leu Leu Asn Trp Cys Met Gln Ile Ala Lys
805 810 815

Gly Met Ser Tyr Leu Glu Asp Val Arg Leu Val His Arg Asp Leu Ala
820 825 830

Ala Arg Asn Val Leu Val Lys Ser Pro Asn His Val Lys Ile Thr Asp
835 840 845

Phe Gly Leu Ala Arg Leu Leu Asp Ile Asp Glu Thr Glu Tyr His Ala
850 855 860

Asp Gly Gly Lys Val Pro Ile Lys Trp Met Ala Leu Glu Ser Ile Leu
865 870 875 880

Arg Arg Arg Phe Thr His Gln Ser Asp Val Trp Ser Tyr Gly Val Thr
885 890 895

Val Trp Glu Leu Met Thr Phe Gly Ala Lys Pro Tyr Asp Gly Ile Pro
900 905 910

Ala Arg Glu Ile Pro Asp Leu Leu Glu Lys Gly Glu Arg Leu Pro Gln
915 920 925

Pro Pro Ile Cys Thr Ile Asp Val Tyr Met Ile Met Val Lys Cys Trp
930 935 940

Met Ile Asp Ser Glu Cys Arg Pro Arg Phe Arg Glu Leu Val Ser Glu
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Phe Ser Arg Met Ala Arg Asp Pro Gln Arg Phe Val Val Ile Gln Asn
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Glu Asp Leu Gly Pro Ala Ser Pro Leu Asp Ser Thr Phe Tyr Arg Ser
980 985 990

Leu Leu Glu Asp Asp Asp Met Gly Asp Leu Val Asp Ala Glu Glu Tyr
995 1000 1005

Leu Val Pro Gln Gln Gly Phe Phe Cys Pro Asp Pro Ala Pro Gly
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Ala Gly Gly Met Val His His Arg His Arg Ser Ser Ser Thr Arg
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Ser Gly Gly Gly Asp Leu Thr Leu Gly Leu Glu Pro Ser Glu Glu
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Glu Ala Pro Arg Ser Pro Leu Ala Pro Ser Glu Gly Ala Gly Ser
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Asp Val Phe Asp Gly Asp Leu Gly Met Gly Ala Ala Lys Gly Leu
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Gln Ser Leu Pro Thr His Asp Pro Ser Pro Leu Gln Arg Tyr Ser
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Glu Asp Pro Thr Val Pro Leu Pro Ser Glu Thr Asp Gly Tyr Val
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Ala Pro Leu Thr Cys Ser Pro Gln Pro Glu Tyr Val Asn Gln Pro
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Asp Val Arg Pro Gln Pro Pro Ser Pro Arg Glu Gly Pro Leu Pro
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Ala Ala Arg Pro Ala Gly Ala Thr Leu Glu Arg Pro Lys Thr Leu
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Ser Pro Gly Lys Asn Gly Val Val Lys Asp Val Phe Ala Phe Gly
 1160 1165 1170

Gly Ala Val Glu Asn Pro Glu Tyr Leu Thr Pro Gln Gly Gly Ala
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Ala Pro Gln Pro His Pro Pro Pro Ala Phe Ser Pro Ala Phe Asp
 1190 1195 1200

Asn Leu Tyr Tyr Trp Asp Gln Asp Pro Pro Glu Arg Gly Ala Pro
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<400> 6

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Leu Ser Leu Gln Arg Met Phe Asn Asn Cys Glu Val Val Leu Gly Asn
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Leu Glu Ile Thr Tyr Val Gln Arg Asn Tyr Asp Leu Ser Phe Leu Lys
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Thr Ile Gln Glu Val Ala Gly Tyr Val Leu Ile Ala Leu Asn Thr Val
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Glu Arg Ile Pro Leu Glu Asn Leu Gln Ile Ile Arg Gly Asn Met Tyr
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Tyr Glu Asn Ser Tyr Ala Leu Ala Val Leu Ser Asn Tyr Asp Ala Asn
115 120 125

Lys Thr Gly Leu Lys Glu Leu Pro Met Arg Asn Leu Gln Glu Ile Leu
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His Gly Ala Val Arg Phe Ser Asn Asn Pro Ala Leu Cys Asn Val Glu
 145 150 155 160

Ser Ile Gln Trp Arg Asp Ile Val Ser Ser Asp Phe Leu Ser Asn Met
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Ser Met Asp Phe Gln Asn His Leu Gly Ser Cys Gln Lys Cys Asp Pro
 180 185 190

Ser Cys Pro Asn Gly Ser Cys Trp Gly Ala Gly Glu Glu Asn Cys Gln
 195 200 205

Lys Leu Thr Lys Ile Ile Cys Ala Gln Gln Cys Ser Gly Arg Cys Arg
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Gly Lys Ser Pro Ser Asp Cys Cys His Asn Gln Cys Ala Ala Gly Cys
 225 230 235 240

Thr Gly Pro Arg Glu Ser Asp Cys Leu Val Cys Arg Lys Phe Arg Asp
 245 250 255

Glu Ala Thr Cys Lys Asp Thr Cys Pro Pro Leu Met Leu Tyr Asn Pro
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Thr Thr Tyr Gln Met Asp Val Asn Pro Glu Gly Lys Tyr Ser Phe Gly
 275 280 285

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Gly Ser Cys Val Arg Ala Cys Gly Ala Asp Ser Tyr Glu Met Glu Glu
 305 310 315 320

Asp Gly Val Arg Lys Cys Lys Lys Cys Glu Gly Pro Cys Arg Lys Val
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Cys Asn Gly Ile Gly Ile Gly Glu Phe Lys Asp Ser Leu Ser Ile Asn
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Ala Thr Asn Ile Lys His Phe Lys Asn Cys Thr Ser Ile Ser Gly Asp
 355 360 365

Leu His Ile Leu Pro Val Ala Phe Arg Gly Asp Ser Phe Thr His Thr
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Pro Pro Leu Asp Pro Gln Glu Leu Asp Ile Leu Lys Thr Val Lys Glu
 385 390 395 400

Ile Thr Gly Phe Leu Leu Ile Gln Ala Trp Pro Glu Asn Arg Thr Asp
 405 410 415

Leu His Ala Phe Glu Asn Leu Glu Ile Ile Arg Gly Arg Thr Lys Gln
420 425 430

His Gly Gln Phe Ser Leu Ala Val Val Ser Leu Asn Ile Thr Ser Leu
435 440 445

Gly Leu Arg Ser Leu Lys Glu Ile Ser Asp Gly Asp Val Ile Ile Ser
450 455 460

Gly Asn Lys Asn Leu Cys Tyr Ala Asn Thr Ile Asn Trp Lys Lys Leu
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Phe Gly Thr Ser Gly Gln Lys Thr Lys Ile Ile Ser Asn Arg Gly Glu
485 490 495

Asn Ser Cys Lys Ala Thr Gly Gln Val Cys His Ala Leu Cys Ser Pro
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Glu Gly Cys Trp Gly Pro Glu Pro Arg Asp Cys Val Ser Cys Arg Asn
515 520 525

Val Ser Arg Gly Arg Glu Cys Val Asp Lys Cys Asn Leu Leu Glu Gly
530 535 540

Glu Pro Arg Glu Phe Val Glu Asn Ser Glu Cys Ile Gln Cys His Pro
545 550 555 560

Glu Cys Leu Pro Gln Ala Met Asn Ile Thr Cys Thr Gly Arg Gly Pro
565 570 575

Asp Asn Cys Ile Gln Cys Ala His Tyr Ile Asp Gly Pro His Cys Val
580 585 590

Lys Thr Cys Pro Ala Gly Val Met Gly Glu Asn Asn Thr Leu Val Trp
595 600 605

Lys Tyr Ala Asp Ala Gly His Val Cys His Leu Cys His Pro Asn Cys
610 615 620

Thr Tyr Gly Cys Thr Gly Pro Gly Leu Glu Gly Cys Pro Thr Asn Gly
625 630 635 640

Pro Lys Ile Pro Ser Ile Ala Thr Gly Met Val Gly Ala Leu Leu Leu
645 650 655

Leu Leu Val Val Ala Leu Gly Ile Gly Leu Phe Met Arg Arg Arg His
660 665 670

Ile Val Arg Lys Arg Thr Leu Arg Arg Leu Leu Gln Glu Arg Glu Leu
675 680 685

Val Glu Pro Leu Thr Pro Ser Gly Glu Ala Pro Asn Gln Ala Leu Leu
690 695 700

Arg Ile Leu Lys Glu Thr Glu Phe Lys Lys Ile Lys Val Leu Gly Ser
705 710 715 720

Gly Ala Phe Gly Thr Val Tyr Lys Gly Leu Trp Ile Pro Glu Gly Glu
725 730 735

Lys Val Lys Ile Pro Val Ala Ile Lys Glu Leu Arg Glu Ala Thr Ser
740 745 750

Pro Lys Ala Asn Lys Glu Ile Leu Asp Glu Ala Tyr Val Met Ala Ser
755 760 765

Val Asp Asn Pro His Val Cys Arg Leu Leu Gly Ile Cys Leu Thr Ser
770 775 780

Thr Val Gln Leu Ile Thr Gln Leu Met Pro Phe Gly Cys Leu Leu Asp
785 790 795 800

Tyr Val Arg Glu His Lys Asp Asn Ile Gly Ser Gln Tyr Leu Leu Asn
805 810 815

Trp Cys Val Gln Ile Ala Lys Gly Met Asn Tyr Leu Glu Asp Arg Arg
820 825 830

Leu Val His Arg Asp Leu Ala Ala Arg Asn Val Leu Val Lys Thr Pro
835 840 845

Gln His Val Lys Ile Thr Asp Phe Gly Leu Ala Lys Leu Leu Gly Ala
850 855 860

Glu Glu Lys Glu Tyr His Ala Glu Gly Gly Lys Val Pro Ile Lys Trp
865 870 875 880

Met Ala Leu Glu Ser Ile Leu His Arg Ile Tyr Thr His Gln Ser Asp
885 890 895

Val Trp Ser Tyr Gly Val Thr Val Trp Glu Leu Met Thr Phe Gly Ser
900 905 910

Lys Pro Tyr Asp Gly Ile Pro Ala Ser Glu Ile Ser Ser Ile Leu Glu
915 920 925

Lys Gly Glu Arg Leu Pro Gln Pro Pro Ile Cys Thr Ile Asp Val Tyr
930 935 940

Met Ile Met Val Lys Cys Trp Met Ile Asp Ala Asp Ser Arg Pro Lys
945 950 955 960

Phe Arg Glu Leu Ile Ile Glu Phe Ser Lys Met Ala Arg Asp Pro Gln

965

970

975

Arg Tyr Leu Val Ile Gln Gly Asp Glu Arg Met His Leu Pro Ser Pro
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Thr Asp Ser Asn Phe Tyr Arg Ala Leu Met Asp Glu Glu Asp Met Asp
 995 1000 1005

Asp Val Val Asp Ala Asp Glu Tyr Leu Ile Pro Gln Gln Gly Phe
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Phe Ser Ser Pro Ser Thr Ser Arg Thr Pro Leu Leu Ser Ser Leu
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Ser Ala Thr Ser Asn Asn Ser Thr Val Ala Cys Ile Asp Arg Asn
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Gly Leu Gln Ser Cys Pro Ile Lys Glu Asp Ser Phe Leu Gln Arg
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Tyr Ser Ser Asp Pro Thr Gly Ala Leu Thr Glu Asp Ser Ile Asp
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Asp Thr Phe Leu Pro Val Pro Glu Tyr Ile Asn Gln Ser Val Pro
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Lys Arg Pro Ala Gly Ser Val Gln Asn Pro Val Tyr His Asn Gln
 1100 1105 1110

Pro Leu Asn Pro Ala Pro Ser Arg Asp Pro His Tyr Gln Asp Pro
 1115 1120 1125

His Ser Thr Ala Val Gly Asn Pro Glu Tyr Leu Asn Thr Val Gln
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Pro Thr Cys Val Asn Ser Thr Phe Asp Ser Pro Ala His Trp Ala
 1145 1150 1155

Gln Lys Gly Ser His Gln Ile Ser Leu Asp Asn Pro Asp Tyr Gln
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Gln Asp Phe Phe Pro Lys Glu Ala Lys Pro Asn Gly Ile Phe Lys
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Gly Ser Thr Ala Glu Asn Ala Glu Tyr Leu Arg Val Ala Pro Gln
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Ser Ser Glu Phe Ile Gly Ala
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<213> Homo sapiens

<400> 8

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Gly Thr Ser Asn Lys Leu Thr Gln Leu Gly Thr Phe Glu Asp His Phe
35 40 45

Leu Ser Leu Gln Arg Met Phe Asn Asn Cys Glu Val Val Leu Gly Asn
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Leu Glu Ile Thr Tyr Val Gln Arg Asn Tyr Asp Leu Ser Phe Leu Lys
65 70 75 80

Thr Ile Gln Glu Val Ala Gly Tyr Val Leu Ile Ala Leu Asn Thr Val
85 90 95

Glu Arg Ile Pro Leu Glu Asn Leu Gln Ile Ile Arg Gly Asn Met Tyr
100 105 110

Tyr Glu Asn Ser Tyr Ala Leu Ala Val Leu Ser Asn Tyr Asp Ala Asn
115 120 125

Lys Thr Gly Leu Lys Glu Leu Pro Met Arg Asn Leu Gln Gly Gln Lys
130 135 140

Cys Asp Pro Ser Cys Pro Asn Gly Ser Cys Trp Gly Ala Gly Glu Glu
145 150 155 160

Asn Cys Gln Lys Leu Thr Lys Ile Ile Cys Ala Gln Gln Cys Ser Gly
165 170 175

Arg Cys Arg Gly Lys Ser Pro Ser Asp Cys Cys His Asn Gln Cys Ala
180 185 190

Ala Gly Cys Thr Gly Pro Arg Glu Ser Asp Cys Leu Val Cys Arg Lys
195 200 205

Phe Arg Asp Glu Ala Thr Cys Lys Asp Thr Cys Pro Pro Leu Met Leu
210 215 220

Tyr Asn Pro Thr Thr Tyr Gln Met Asp Val Asn Pro Glu Gly Lys Tyr
225 230 235 240

Ser Phe Gly Ala Thr Cys Val Lys Lys Cys Pro Arg Asn Tyr Val Val
245 250 255

Thr Asp His Gly Ser Cys Val Arg Ala Cys Gly Ala Asp Ser Tyr Glu
260 265 270

Met Glu Glu Asp Gly Val Arg Lys Cys Lys Lys Cys Glu Gly Pro Cys
275 280 285

Arg Lys Val Cys Asn Gly Ile Gly Ile Gly Glu Phe Lys Asp Ser Leu
290 295 300

Ser Ile Asn Ala Thr Asn Ile Lys His Phe Lys Asn Cys Thr Ser Ile
305 310 315 320

Ser Gly Asp Leu His Ile Leu Pro Val Ala Phe Arg Gly Asp Ser Phe
325 330 335

Thr His Thr Pro Pro Leu Asp Pro Gln Glu Leu Asp Ile Leu Lys Thr

340

345

350

Val Lys Glu Ile Thr Gly Phe Leu Leu Ile Gln Ala Trp Pro Glu Asn
 355 360 365

Arg Thr Asp Leu His Ala Phe Glu Asn Leu Glu Ile Ile Arg Gly Arg
 370 375 380

Thr Lys Gln His Gly Gln Phe Ser Leu Ala Val Val Ser Leu Asn Ile
 385 390 395 400

Thr Ser Leu Gly Leu Arg Ser Leu Lys Glu Ile Ser Asp Gly Asp Val
 405 410 415

Ile Ile Ser Gly Asn Lys Asn Leu Cys Tyr Ala Asn Thr Ile Asn Trp
 420 425 430

Lys Lys Leu Phe Gly Thr Ser Gly Gln Lys Thr Lys Ile Ile Ser Asn
 435 440 445

Arg Gly Glu Asn Ser Cys Lys Ala Thr Gly Gln Val Cys His Ala Leu
 450 455 460

Cys Ser Pro Glu Gly Cys Trp Gly Pro Glu Pro Arg Asp Cys Val Ser
 465 470 475 480

Cys Arg Asn Val Ser Arg Gly Arg Glu Cys Val Asp Lys Cys Asn Leu
 485 490 495

Leu Glu Gly Glu Pro Arg Glu Phe Val Glu Asn Ser Glu Cys Ile Gln
 500 505 510

Cys His Pro Glu Cys Leu Pro Gln Ala Met Asn Ile Thr Cys Thr Gly
 515 520 525

Arg Gly Pro Asp Asn Cys Ile Gln Cys Ala His Tyr Ile Asp Gly Pro
 530 535 540

His Cys Val Lys Thr Cys Pro Ala Gly Val Met Gly Glu Asn Asn Thr
 545 550 555 560

Leu Val Trp Lys Tyr Ala Asp Ala Gly His Val Cys His Leu Cys His
 565 570 575

Pro Asn Cys Thr Tyr Gly Cys Thr Gly Pro Gly Leu Glu Gly Cys Pro
 580 585 590

Thr Asn Gly Pro Lys Ile Pro Ser Ile Ala Thr Gly Met Val Gly Ala
 595 600 605

Leu Leu Leu Leu Leu Val Val Ala Leu Gly Ile Gly Leu Phe Met Arg
 610 615 620

Arg Arg His Ile Val Arg Lys Arg Thr Leu Arg Arg Leu Leu Gln Glu
625 630 635 640

Arg Glu Leu Val Glu Pro Leu Thr Pro Ser Gly Glu Ala Pro Asn Gln
645 650 655

Ala Leu Leu Arg Ile Leu Lys Glu Thr Glu Phe Lys Lys Ile Lys Val
660 665 670

Leu Gly Ser Gly Ala Phe Gly Thr Val Tyr Lys Gly Leu Trp Ile Pro
675 680 685

Glu Gly Glu Lys Val Lys Ile Pro Val Ala Ile Lys Glu Leu Arg Glu
690 695 700

Ala Thr Ser Pro Lys Ala Asn Lys Glu Ile Leu Asp Glu Ala Tyr Val
705 710 715 720

Met Ala Ser Val Asp Asn Pro His Val Cys Arg Leu Leu Gly Ile Cys
725 730 735

Leu Thr Ser Thr Val Gln Leu Ile Thr Gln Leu Met Pro Phe Gly Cys
740 745 750

Leu Leu Asp Tyr Val Arg Glu His Lys Asp Asn Ile Gly Ser Gln Tyr
755 760 765

Leu Leu Asn Trp Cys Val Gln Ile Ala Lys Gly Met Asn Tyr Leu Glu
770 775 780

Asp Arg Arg Leu Val His Arg Asp Leu Ala Ala Arg Asn Val Leu Val
785 790 795 800

Lys Thr Pro Gln His Val Lys Ile Thr Asp Phe Gly Leu Ala Lys Leu
805 810 815

Leu Gly Ala Glu Glu Lys Glu Tyr His Ala Glu Gly Gly Lys Val Pro
820 825 830

Ile Lys Trp Met Ala Leu Glu Ser Ile Leu His Arg Ile Tyr Thr His
835 840 845

Gln Ser Asp Val Trp Ser Tyr Gly Val Thr Val Trp Glu Leu Met Thr
850 855 860

Phe Gly Ser Lys Pro Tyr Asp Gly Ile Pro Ala Ser Glu Ile Ser Ser
865 870 875 880

Ile Leu Glu Lys Gly Glu Arg Leu Pro Gln Pro Pro Ile Cys Thr Ile
885 890 895

Asp Val Tyr Met Ile Met Val Lys Cys Trp Met Ile Asp Ala Asp Ser
900 905 910

Arg Pro Lys Phe Arg Glu Leu Ile Ile Glu Phe Ser Lys Met Ala Arg
915 920 925

Asp Pro Gln Arg Tyr Leu Val Ile Gln Gly Asp Glu Arg Met His Leu
930 935 940

Pro Ser Pro Thr Asp Ser Asn Phe Tyr Arg Ala Leu Met Asp Glu Glu
945 950 955 960

Asp Met Asp Asp Val Val Asp Ala Asp Glu Tyr Leu Ile Pro Gln Gln
965 970 975

Gly Phe Phe Ser Ser Pro Ser Thr Ser Arg Thr Pro Leu Leu Ser Ser
980 985 990

Leu Ser Ala Thr Ser Asn Asn Ser Thr Val Ala Cys Ile Asp Arg Asn
995 1000 1005

Gly Leu Gln Ser Cys Pro Ile Lys Glu Asp Ser Phe Leu Gln Arg
1010 1015 1020

Tyr Ser Ser Asp Pro Thr Gly Ala Leu Thr Glu Asp Ser Ile Asp
1025 1030 1035

Asp Thr Phe Leu Pro Val Pro Gly Glu Trp Leu Val Trp Lys Gln
1040 1045 1050

Ser Cys Ser Ser Thr Ser Ser Thr His Ser Ala Ala Ala Ser Leu
1055 1060 1065

Gln Cys Pro Ser Gln Val Leu Pro Pro Ala Ser Pro Glu Gly Glu
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Thr Val Ala Asp Leu Gln Thr Gln
1085 1090

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<211> 2832
<212> DNA
<213> Homo sapiens

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gtccgagcct gtggggccga cagctatgag atggaggaag acggcgtccg caagtgtaag 180
aagtgcgaag ggccttgccg caaagtgtgt aacggaatag gtattggtga atttaaagac 240
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gatctccaca tcctgccggt ggcatthtagg ggtgactcct tcacacatac tcctcctctg	360
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aatttgtgct atgcaaatac aataaactgg aaaaaactgt ttgggacctc cggtcagaaa	660
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gacaaccctg actaccagca ggacttcttt cccaaggaag ccaagccaaa tggcatcttt	2760
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 <211> 943
 <212> PRT
 <213> Homo sapiens

 <400> 10

Met Arg Pro Ser Gly Thr Ala Gly Ala Ala Leu Leu Ala Leu Leu Ala	1	5	10	15
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Val Val Thr Asp His Gly Ser Cys Val Arg Ala Cys Gly Ala Asp Ser	35	40	45	
Tyr Glu Met Glu Glu Asp Gly Val Arg Lys Cys Lys Lys Cys Glu Gly	50	55	60	
Pro Cys Arg Lys Val Cys Asn Gly Ile Gly Ile Gly Glu Phe Lys Asp	65	70	75	80
Ser Leu Ser Ile Asn Ala Thr Asn Ile Lys His Phe Lys Asn Cys Thr	85	90	95	
Ser Ile Ser Gly Asp Leu His Ile Leu Pro Val Ala Phe Arg Gly Asp	100	105	110	
Ser Phe Thr His Thr Pro Pro Leu Asp Pro Gln Glu Leu Asp Ile Leu	115	120	125	
Lys Thr Val Lys Glu Ile Thr Gly Phe Leu Leu Ile Gln Ala Trp Pro	130	135	140	
Glu Asn Arg Thr Asp Leu His Ala Phe Glu Asn Leu Glu Ile Ile Arg	145	150	155	160
Gly Arg Thr Lys Gln His Gly Gln Phe Ser Leu Ala Val Val Ser Leu	165	170	175	

Asn Ile Thr Ser Leu Gly Leu Arg Ser Leu Lys Glu Ile Ser Asp Gly
180 185 190

Asp Val Ile Ile Ser Gly Asn Lys Asn Leu Cys Tyr Ala Asn Thr Ile
195 200 205

Asn Trp Lys Lys Leu Phe Gly Thr Ser Gly Gln Lys Thr Lys Ile Ile
210 215 220

Ser Asn Arg Gly Glu Asn Ser Cys Lys Ala Thr Gly Gln Val Cys His
225 230 235 240

Ala Leu Cys Ser Pro Glu Gly Cys Trp Gly Pro Glu Pro Arg Asp Cys
245 250 255

Val Ser Cys Arg Asn Val Ser Arg Gly Arg Glu Cys Val Asp Lys Cys
260 265 270

Asn Leu Leu Glu Gly Glu Pro Arg Glu Phe Val Glu Asn Ser Glu Cys
275 280 285

Ile Gln Cys His Pro Glu Cys Leu Pro Gln Ala Met Asn Ile Thr Cys
290 295 300

Thr Gly Arg Gly Pro Asp Asn Cys Ile Gln Cys Ala His Tyr Ile Asp
305 310 315 320

Gly Pro His Cys Val Lys Thr Cys Pro Ala Gly Val Met Gly Glu Asn
325 330 335

Asn Thr Leu Val Trp Lys Tyr Ala Asp Ala Gly His Val Cys His Leu
340 345 350

Cys His Pro Asn Cys Thr Tyr Gly Cys Thr Gly Pro Gly Leu Glu Gly
355 360 365

Cys Pro Thr Asn Gly Pro Lys Ile Pro Ser Ile Ala Thr Gly Met Val
370 375 380

Gly Ala Leu Leu Leu Leu Val Val Ala Leu Gly Ile Gly Leu Phe
385 390 395 400

Met Arg Arg Arg His Ile Val Arg Lys Arg Thr Leu Arg Arg Leu Leu
405 410 415

Gln Glu Arg Gly Leu Val Glu Pro Leu Thr Pro Ser Gly Glu Ala Pro
420 425 430

Asn Gln Ala Leu Leu Arg Ile Leu Lys Glu Thr Glu Phe Lys Lys Ile
435 440 445

Lys Val Leu Gly Ser Gly Ala Phe Gly Thr Val Tyr Lys Gly Leu Trp

450		455		460	
Ile Pro Glu Gly Glu Lys Val Lys Ile Pro Val Ala Ile Lys Glu Leu					
465		470		475	480
Arg Glu Ala Thr Ser Pro Lys Ala Asn Lys Glu Ile Leu Asp Glu Ala					
	485		490		495
Tyr Val Met Ala Ser Val Asp Asn Pro His Val Cys Arg Leu Leu Gly					
	500		505		510
Ile Cys Leu Thr Ser Thr Val Gln Leu Ile Thr Gln Leu Met Pro Phe					
	515		520		525
Gly Cys Leu Leu Asp Tyr Val Arg Glu His Lys Asp Asn Ile Gly Ser					
	530		535		540
Gln Tyr Leu Leu Asn Trp Cys Val Gln Ile Ala Lys Gly Met Asn Tyr					
545		550		555	560
Leu Glu Asp Arg Arg Leu Val His Arg Asp Leu Ala Ala Arg Asn Val					
	565		570		575
Leu Val Lys Thr Pro Gln His Val Lys Ile Thr Asp Phe Gly Leu Ala					
	580		585		590
Lys Leu Leu Gly Ala Glu Glu Lys Glu Tyr His Ala Glu Gly Gly Lys					
	595		600		605
Val Pro Ile Lys Trp Met Ala Leu Glu Ser Ile Leu His Arg Ile Tyr					
	610		615		620
Thr His Gln Ser Asp Val Trp Ser Tyr Gly Val Thr Val Trp Glu Leu					
625		630		635	640
Met Thr Phe Gly Ser Lys Pro Tyr Asp Gly Ile Pro Ala Ser Glu Ile					
	645		650		655
Ser Ser Ile Leu Glu Lys Gly Glu Arg Leu Pro Gln Pro Pro Ile Cys					
	660		665		670
Thr Ile Asp Val Tyr Met Ile Met Val Lys Cys Trp Met Ile Asp Ala					
	675		680		685
Asp Ser Arg Pro Lys Phe Arg Glu Leu Ile Ile Glu Phe Ser Lys Met					
	690		695		700
Ala Arg Asp Pro Gln Arg Tyr Leu Val Ile Gln Gly Asp Glu Arg Met					
705		710		715	720
His Leu Pro Ser Pro Thr Asp Ser Asn Phe Tyr Arg Ala Leu Met Asp					
	725		730		735

Glu Glu Asp Met Asp Asp Val Val Asp Ala Asp Glu Tyr Leu Ile Pro
740 745 750

Gln Gln Gly Phe Phe Ser Ser Pro Ser Thr Ser Arg Thr Pro Leu Leu
755 760 765

Ser Ser Leu Ser Ala Thr Ser Asn Asn Ser Thr Val Ala Cys Ile Asp
770 775 780

Arg Asn Gly Leu Gln Ser Cys Pro Ile Lys Glu Asp Ser Phe Leu Gln
785 790 795 800

Arg Tyr Ser Ser Asp Pro Thr Gly Ala Leu Thr Glu Asp Ser Ile Asp
805 810 815

Asp Thr Phe Leu Pro Val Pro Glu Tyr Ile Asn Gln Ser Val Pro Lys
820 825 830

Arg Pro Ala Gly Ser Val Gln Asn Pro Val Tyr His Asn Gln Pro Leu
835 840 845

Asn Pro Ala Pro Ser Arg Asp Pro His Tyr Gln Asp Pro His Ser Thr
850 855 860

Ala Val Gly Asn Pro Glu Tyr Leu Asn Thr Val Gln Pro Thr Cys Val
865 870 875 880

Asn Ser Thr Phe Asp Ser Pro Ala His Trp Ala Gln Lys Gly Ser His
885 890 895

Gln Ile Ser Leu Asp Asn Pro Asp Tyr Gln Gln Asp Phe Phe Pro Lys
900 905 910

Glu Ala Lys Pro Asn Gly Ile Phe Lys Gly Ser Thr Ala Glu Asn Ala
915 920 925

Glu Tyr Leu Arg Val Ala Pro Gln Ser Ser Glu Phe Ile Gly Ala
930 935 940