

HETEROARYLAMIDOPYRIDINOL DERIVATIVE AND
PHARMACEUTICAL COMPOSITION COMPRISING SAME AS ACTIVE
INGREDIENT FOR PREVENTION OR TREATMENT OF AUTOIMMUNE
DISEASE

5

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a
10 heteroarylamidopyridinol derivative and a
pharmaceutical composition comprising the same as an
active ingredient for the prevention or treatment of
autoimmune diseases such as inflammatory bowel disease
and rheumatoid arthritis.

15

2. Description of the Related Art

Immunity is one of the self-protection systems of
a living body against all the foreign polymers that
invade or are injected into the living tissues. All
20 normal individuals do not react detrimentally to
antigens constituting the self, whereas they have the
ability to recognize and react to non-self antigens
and remove them. However, if the host's immune system
fails to distinguish foreign antigens from self-
25 antigens and induces an abnormal immune response, the

immune cells in the body attack their own cellular components and cause various diseases, which are called autoimmune diseases.

Autoimmune disease is caused by a variety of
5 causes, such as heredity, stress, hormones, heavy metals, food, infection, and pesticides, and occurs in about 5 to 8% of the world's population. Examples of autoimmune diseases include inflammatory bowel disease, autism, asthma, type 1 diabetes, rheumatoid
10 arthritis, polymyalgia rheumatica, ankylosing spondylitis, psoriatic arthritis, psoriasis, eczema, scleroderma, vitiligo, multiple sclerosis, IL-17-induced dementia, peripheral neuritis, uveitis, dry eye syndrome, organ transplantation rejection, and
15 cancer. Currently, anti-inflammatory and immunosuppressive drugs are used as therapeutic agents for autoimmune disease, but some patients are resistant to these drugs, making treatment difficult.

Among the autoimmune diseases, inflammatory bowel
20 disease is an inflammatory disease of the digestive tract with a chronic and recurrent course, and is classified into two diseases: ulcerative colitis and Crohn's disease. The exact cause of the disease is not yet known, but it is caused by an inappropriate immune
25 response to bacteria in the intestinal tract in a

person with a genetic predisposition. Continuous or inappropriate activation of the enteric immune system, such as neutrophils and macrophages, which are innate immune cells, as well as lymphocytes, which are
5 acquired immune cells, eventually leads to mucosal destruction and ulceration. Various inflammatory cytokines are produced and secreted in the mucous membrane of the intestinal tract in an inflamed state, and among them, TNF- α (tumor necrosis factor- α) is
10 highly expressed in the intestinal lumen and epithelial cells of ulcerative colitis patients. According to recent studies, TNF- α is known to play an important role in the pathogenesis of ulcerative colitis.

15 Infliximab, an anti-TNF- α antibody, is known to be effective not only in the treatment of furuncles, but also in the treatment of Crohn's disease previously untreated. However, such treatment is expensive and causes side effects such as fluid
20 reactions or infectious complications in some patients. Tofacitinib (Xeljanz[®]), a Janus kinase (JAK) inhibitor, has been confirmed to have therapeutic efficacy in ulcerative colitis, but has been confirmed to be ineffective in Crohn's disease. In other words,
25 there are still no reliable oral treatment agents for

inflammatory bowel disease, so there is a need to develop an effective and low-cost oral treatment for the disease.

Among the autoimmune diseases, rheumatoid
5 arthritis is a disease that is common enough to account for about 1% of the adult population, and is a disease that results in joint destruction and joint deformity in most patients, eventually resulting in disability. In the pathophysiology of rheumatoid
10 arthritis, the disease is reported to occur by the activation of autoreactive T cells specific to neopeptides made by the antigens in the joint such as collagen or proteoglycan due to chronic inflammation after an inflammatory response according to viral or
15 bacterial infection. The correlation between rheumatoid arthritis and T lymphocytes as well as B lymphocytes and synovial cells is well known. Important cytokines associated with rheumatoid arthritis are $\text{TNF-}\alpha$, IL-1, and IL-6. They increase the
20 expression of adhesion molecules in endothelial cells to increase the influx of leukocytes into the joint, and promote the secretion of matrix metalloproteinase in synovial cells and chondrocytes to induce tissue destruction. Among the newly developed drugs for the
25 treatment of rheumatoid arthritis, anti- $\text{TNF-}\alpha$ antibody

preparations are the most representative, and among them, etanercept (Enbrel®), infliximab (Remicade®), and adalimumab (Humira®) are the most commonly used drugs.

5 However, these drugs are expensive and the inconvenience of administration is an obstacle in treatment. In the case of tofacitinib, which was recently developed as a treatment for rheumatoid arthritis that can be administered orally,
10 diverticulitis was reported as a 'serious' infection in a series of clinical trials targeting rheumatoid arthritis patients. In particular, as diverticulum perforation, one of the cases of gastrointestinal perforation, was reported in clinical trials, both the
15 'caution' and 'adverse reactions' sections were updated by the FDA in December 2015. To date, there is no development of a safe and effective oral therapeutic agent as a drug targeting TNF- α or TNF receptor, which has emerged as the most effective
20 therapeutic target for rheumatoid arthritis. Therefore, there is a request for the development of an effective, low-cost, safe, and highly effective oral rheumatoid arthritis therapeutic agent targeting the same.

T cells, which play a central role in the immune system, a biological defense system against various pathogens, exist as various types of differentiated cells. Th1 cells are involved in cell-mediated immunity, Th2 cells are involved in humoral immunity, Th17 cells are involved in infectious and inflammatory diseases, and Treg cells are responsible for maintaining homeostasis by suppressing immunity. However, it is known that autoimmune disease occurs when the activities of Th1 cells and Th17 cells are abnormally increased, and immune disease occurs when the activity of Th2 cells is abnormally increased due to hypersensitivity reaction. Since Treg cells that can regulate the activity of these cells have the property of controlling the inflammatory response by suppressing the functions of abnormally activated immune cells, many experiments have been reported to treat immune diseases through the action of increasing the activity of Treg cells. In the case of autoimmune disease that is not controlled by Treg cells, the development of therapeutic agents for autoimmune disease targeting the inhibition of the activations of Th1 and Th17 cells has been highlighted. In addition to treating immune diseases by inhibiting the activation of T cells, therapies that control the

amount of cytokines secreted from immune cells and
therapies using antibodies targeting cytokines
secreted from immune cells are being developed.
However, among them, the method using antibodies has
5 problems in that the manufacturing cost is high and
administration is inconvenient. Therefore, there is a
need to develop a novel low molecular weight compound
immune disease treatment agent that can be
administered orally with excellent therapeutic and
10 preventive effects on various autoimmune diseases.

SUMMARY OF THE INVENTION

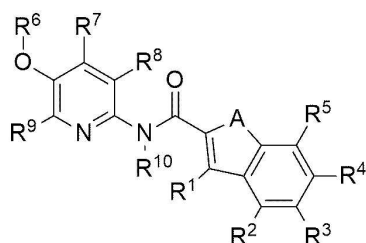
It is an object of the present invention to
15 provide a heteroarylamidopyridinol derivative.

It is another object of the present invention to
provide a method for preparing a
heteroarylamidopyridinol derivative.

It is another object of the present invention to
20 provide a pharmaceutical composition comprising a
heteroarylamidopyridinol derivative as an active
ingredient for the prevention or treatment of
autoimmune disease.

To achieve the above objects, in one aspect of the present invention, the present invention provides a compound represented by formula 1, an isomer thereof, a solvate thereof, a hydrate thereof or a
5 pharmaceutically acceptable salt thereof:

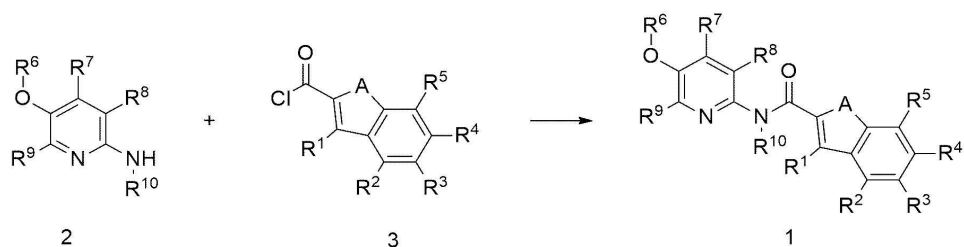
[Formula 1]



(In formula 1,
A, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, and R¹⁰ are
10 as defined in this specification).

In another aspect of the present invention, the present invention provides a method for preparing a compound represented by formula 1 comprising a step of
15 preparing a compound represented by formula 1 by reacting a compound represented by formula 2 with a compound represented by formula 3, as shown in reaction formula 1 below:

[Reaction Formula 1]



(In reaction formula 1,

A, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, and R¹⁰ are as defined in this specification).

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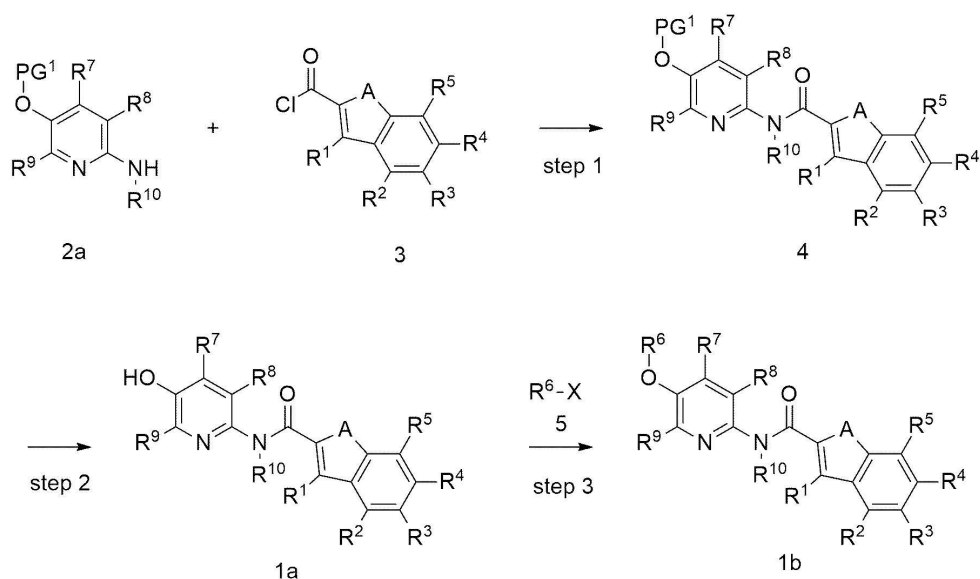
In another aspect of the present invention, the present invention provides a method for preparing a compound represented by formula 1 comprising the following steps, as shown in reaction formula 2 below:

10 preparing a compound represented by formula 4 by reacting a compound represented by formula 2a with a compound represented by formula 3 (step 1);

preparing a compound represented by formula 1a by deprotecting the compound represented by formula 4
15 obtained in step 1 above (step 2); and

preparing a compound represented by formula 1b by reacting the compound represented by formula 1a obtained in step 2 above with a compound represented by formula 5 (step 3):

20 [Reaction Formula 2]



(In reaction formula 2,

A, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, and R¹⁰ are as defined in this specification except when R⁶ is hydrogen;

the compound represented by formula 1a is a derivative of formula 1 wherein R⁶ is hydrogen;

the compound represented by formula 1b is a derivative of formula 1 except when R⁶ is hydrogen;

PG¹ is an alcohol protecting group selected from the group consisting of acetyl (Ac), benzoyl (Bz), benzyl (Bn), methylthiomethyl ether, MEM (β-methoxyethoxymethyl ether), DMT (dimethoxytrityl, [bis-(4-methoxyphenyl)phenylmethyl]), MOM (methoxymethyl ether), MMT (methoxytrityl [(4-methoxyphenyl)diphenylmethyl]), PMP (p-methoxybenzyl

ether), Piv (pivaloyl), THP (tetrahydropyranyl), THF (tetrahydrofuran) and Trityl (triphenylmethyl, Tr); and

X is halogen).

5

In another aspect of the present invention, the present invention provides a pharmaceutical composition comprising a compound represented by formula 1, an isomer thereof, a solvate thereof, a
10 hydrate thereof, or a pharmaceutically acceptable salt thereof as an active ingredient for the prevention or treatment of autoimmune disease.

In another aspect of the present invention, the
15 present invention provides a health functional food comprising a compound represented by formula 1, an isomer thereof, a solvate thereof, a hydrate thereof, or a pharmaceutically acceptable salt thereof as an active ingredient for the prevention or amelioration
20 of autoimmune disease.

In another aspect of the present invention, the present invention provides a method for preventing or treating autoimmune disease, which comprises a step of
25 administering a pharmaceutical composition or a health

functional food comprising a compound represented by formula 1, an isomer thereof, a solvate thereof, a hydrate thereof, or a pharmaceutically acceptable salt thereof as an active ingredient to a subject in need.

5

In another aspect of the present invention, the present invention provides a use of the pharmaceutical composition or the health functional food above comprising a compound represented by formula 1, an
10 isomer thereof, a solvate thereof, a hydrate thereof, or a pharmaceutically acceptable salt thereof as an active ingredient for the prevention or treatment of autoimmune disease.

ADVANTAGEOUS EFFECT

The heteroarylamidopyridinol derivative of the present invention exhibits an excellent effect of
5 inhibiting TNF- α - or IL-6-induced monocyte adhesion to gut epithelial cells and is proven to have a therapeutic effect on inflammatory bowel disease and rheumatoid arthritis in vivo. Thus, the heteroarylamidopyridinol derivative can be
10 advantageously used for the treatment of autoimmune disease, specifically, inflammatory bowel disease or rheumatoid arthritis.

BRIEF DESCRIPTION OF THE DRAWINGS

15

Figure 1 is a set of diagrams showing the results of measuring the intestinal mucosal damage recovery effect according to the treatment of the compound of the present invention in a TNBS-induced inflammatory
20 bowel disease animal model in Experimental Example 3. Figure 1A: a graph showing the degree of colon mucosa damage and recovery by scoring, Figure 1B: images of the colon tissue stained with hematoxylin & eosin.

Figure 2A is a schematic diagram showing the drug
25 administration time for measuring the pharmacological

effect of the compound of the present invention in the DSS-induced chronic enteritis animal model of Experimental Example 4.

Figure 2B is a graph showing the changes in the
5 body weight according to the treatment of the compound of the present invention in the DSS-induced chronic enteritis animal model of Experimental Example 4.

Figure 2C is a diagram showing the morphological changes of the colon according to the treatment of the
10 compound of the present invention in the DSS-induced chronic enteritis animal model of Experimental Example 4.

Figure 2D is a graph showing the changes in the intestinal weight according to the treatment of the
15 compound of the present invention in the DSS-induced chronic enteritis animal model of Experimental Example 4.

Figure 3A is a schematic diagram showing the drug administration time for measuring the pharmacological
20 effect of the compound of the present invention in the DSS-induced acute enteritis animal model of Experimental Example 4.

Figure 3B is a graph showing the changes in the body weight according to the treatment of the compound

of the present invention in the DSS-induced acute enteritis animal model of Experimental Example 4.

Figure 3C is a diagram showing the morphological changes of the colon according to the treatment of the
5 compound of the present invention in the DSS-induced acute enteritis animal model of Experimental Example 4.

Figure 3D is a graph showing the changes in the intestinal weight according to the treatment of the
10 compound of the present invention in the DSS-induced acute enteritis animal model of Experimental Example 4.

Figure 4 is a set of diagrams showing the degree of damage of the intestinal mucosa by performing
15 hematoxylin-eosin staining on the intestinal tissue after observing the shape of the mouse colon in the concentration-dependent efficacy measurement experiment of Experimental Example 4. Figure 4A: a graph showing the results of scoring and comparing the
20 degree of colon mucosa damage, Figure 4B: images of the colon tissue stained with hematoxylin & eosin after morphology observation.

Figure 5A is a graph showing the arthritis score according to the treatment of the compound of the

present invention in the rheumatoid animal model of Experimental Example 5.

Figure 5B is a graph showing the changes of the mouse paw thickness according to the treatment of the compound of the present invention in the rheumatoid animal model of Experimental Example 5.

Figure 5C is a graph showing the changes of the mouse body weight according to the treatment of the compound of the present invention in the rheumatoid animal model of Experimental Example 5.

Figure 6 is a set of photographic images showing the weekly change in the degree of arthritis according to the treatment of the compound of the present invention in the rheumatoid animal model of Experimental Example 5.

Figure 7 is a set of images showing the degree of the articular tissue recovery according to the treatment of the compound of the present invention by hematoxylin & eosin staining and safranin O staining in the rheumatoid animal model of Experimental Example 5 in terms of scores. Figure 7A: hematoxylin & eosin staining and safranin O stained images, Figure 7B: a graph showing the degree of the articular tissue recovery converted to scores.

Figure 8A is a set of graphs showing the results of analyzing the total number of immune cells in the spleen according to the treatment of the compound of the present invention in the rheumatoid animal model
5 of Experimental Example 5.

Figure 8B is a set of graphs showing the results of analyzing the number of inflammatory cells in the spleen according to the treatment of the compound of the present invention in the rheumatoid animal model
10 of Experimental Example 5.

Figure 8C is a set of graphs showing the results of analyzing the number of inflammatory cells in the draining lymph node according to the treatment of the compound of the present invention in the rheumatoid
15 animal model of Experimental Example 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

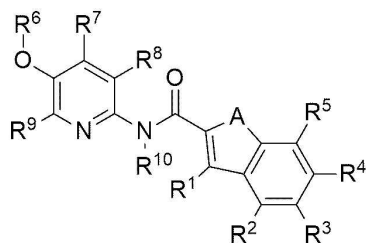
Hereinafter, the present invention is described
20 in detail.

The embodiments of this invention can be modified in various other forms, and the scope of the present invention is not limited to the embodiments described
25 below. It is well understood by those in the art who

has the average knowledge on this field that the
embodiments of the present invention are given to
explain the present invention more precisely. In
addition, the "inclusion" of an element throughout the
5 specification does not exclude other elements, but may
include other elements, unless specifically stated
otherwise.

In one aspect of the present invention, the
10 present invention provides a compound represented by
formula 1, an isomer thereof, a solvate thereof, a
hydrate thereof or a pharmaceutically acceptable salt
thereof.

[Formula 1]



15

(In formula 1,

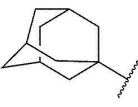
A is NR^a , O or S, wherein, the R^a is hydrogen or
straight chained or branched C_{1-5} alkyl;

R^1 , R^2 , R^3 , R^4 , and R^5 are independently hydrogen,
20 halogen, straight chained or branched C_{1-5} alkyl or
straight chained or branched C_{1-5} alkoxy, wherein the

alkyl and alkoxy can be independently substituted with one or more halogens;

R^6 is hydrogen, straight chained or branched C_{1-5} alkyl, $-(CH_2)_mC(=O)NH(CH_2)_nR^b$ or $-C(=O)R^c$, wherein the
5 alkyl can be substituted with one or more halogens, and m and n are independently integers of 0 to 5,

R^b is hydrogen, straight chained or branched C_{1-10} alkyl, C_{3-10} cycloalkyl or C_{6-10} aryl,

R^c is adamantanyl (, 3 - 10 membered
10 heterocycloalkyl containing one or more hetero atoms selected from the group consisting of N, O and S, C_{6-10} aryl, or 5 - 10 membered heteroaryl containing one or more hetero atoms selected from the group consisting of N, O and S, wherein the aryl and heteroaryl can be
15 independently substituted with at least one selected from the group consisting of halogen, straight chained or branched C_{1-5} alkyl and straight chained or branched C_{1-5} alkoxy;

R^7 , R^8 , and R^9 are independently straight chained
20 or branched C_{1-5} alkyl; and

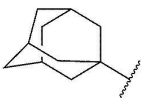
R^{10} is hydrogen or straight chained or branched C_{1-5} alkyl).

In formula 1 above, A is NR^a , O or S, wherein the R^a is hydrogen or straight chained or branched C_{1-3} alkyl;

R^1 , R^2 , R^3 , R^4 , and R^5 are independently hydrogen,
5 halogen, straight chained or branched C_{1-3} alkyl, or straight chained or branched C_{1-3} alkoxy, wherein the alkyl and alkoxy can be independently substituted with one or more halogens;

R^6 is hydrogen, straight chained or branched C_{1-3}
10 alkyl, $-(\text{CH}_2)_m\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{R}^b$, or $-\text{C}(=\text{O})\text{R}^c$, wherein the alkyl can be substituted with one or more halogens, and m and n are independently integers of 0 to 3,

R^b is hydrogen, straight chained or branched C_{1-6} alkyl, C_{3-8} cycloalkyl or phenyl,

15 R^c is adamantanyl (, 3 - 8 membered heterocycloalkyl containing one or more hetero atoms selected from the group consisting of N, O and S, phenyl, or 5 - 6 membered heteroaryl containing one or more hetero atoms selected from the group consisting
20 of N, O and S, wherein the phenyl and heteroaryl can be independently substituted with at least one selected from the group consisting of halogen, straight chained or branched C_{1-3} alkyl and straight chained or branched C_{1-3} alkoxy;

R^7 , R^8 , and R^9 are independently straight chained or branched C_{1-3} alkyl; and

R^{10} is hydrogen or straight chained or branched C_{1-3} alkyl.

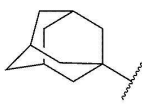
5

In formula 1 above, A is NR^a , O or S, wherein the R^a is hydrogen or methyl;

R^1 , R^2 , R^3 , R^4 , and R^5 are independently hydrogen, -Cl, -Br, -F, methyl, methoxy, -CF₃ or -OCF₃;

10 R^6 is hydrogen, methyl, $-(CH_2)_mC(=O)NH(CH_2)_nR^b$, or $-C(=O)R^c$, wherein m is 1, and n is 0 or 1,

R^b is hydrogen, straight chained or branched C_{1-3} alkyl, C_{3-6} cycloalkyl or phenyl,

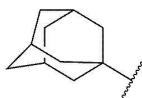
R^c is adamantanyl (, 6 membered
15 heterocycloalkyl containing one or more hetero atoms selected from the group consisting of N, O and S, phenyl, or 6 membered heteroaryl containing one or more hetero atoms selected from the group consisting of N, O and S, wherein the phenyl and heteroaryl can
20 be independently substituted with at least one selected from the group consisting of halogen, and straight chained or branched C_{1-3} alkoxy;

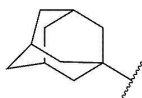
R^7 , R^8 , and R^9 are methyl; and

R^{10} is hydrogen or methyl.

In formula 1 above, R⁶ is hydrogen, methyl, -
(CH₂)C(=O)NHR^b, or -C(=O)R^c,

R^b is hydrogen, isopropyl, cyclopropyl,
5 cyclohexyl, phenyl or benzyl,



R^c is adamantanyl (), morpholinyl, phenyl
or pyridinyl, wherein the phenyl and pyridinyl can be
independently substituted with at least one selected
from the group consisting of F, Cl and methoxy.

10

Examples of the compound represented by formula 1
according to the present invention include the
following compounds:

- <1> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-
15 yl)-1H-indole-2-carboxamide; <2> N-(5-(benzyloxy)-
3,4,6-trimethylpyridin-2-yl)-1-methyl-1H-indole-2-
carboxamide; <3> N-(5-(benzyloxy)-3,4,6-
trimethylpyridin-2-yl)-7-bromo-1H-indole-2-
carboxamide; <4> N-(5-(benzyloxy)-3,4,6-
20 trimethylpyridin-2-yl)-6-chloro-1H-indole-2-
carboxamide; <5> N-(5-(benzyloxy)-3,4,6-
trimethylpyridin-2-yl)-6-bromo-1H-indole-2-
carboxamide; <6> N-(5-(benzyloxy)-3,4,6-
trimethylpyridin-2-yl)-5-fluoro-1H-indole-2-

carboxamide; <7> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromo-1H-indole-2-carboxamide;

carboxamide; <8> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chloro-1H-indole-2-carboxamide;

5 carboxamide; <9> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methyl-1H-indole-2-carboxamide;

carboxamide; <10> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethyl)-1H-indole-2-carboxamide;

10 trimethylpyridin-2-yl)-5-(trifluoromethoxy)-1H-indole-2-carboxamide; <11> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-indole-2-carboxamide;

carboxamide; <12> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-carboxamide;

15 carboxamide; <13> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide;

carboxamide; <14> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide; <15> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chlorobenzofuran-2-carboxamide;

20 chlorobenzofuran-2-carboxamide; <16> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromobenzofuran-2-carboxamide;

carboxamide; <17> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-7-methoxybenzofuran-2-carboxamide;

carboxamide; <18> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-methylbenzofuran-2-carboxamide;

25 trimethylpyridin-2-yl)-3-methylbenzofuran-2-carboxamide; <19> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethyl)-1H-indole-2-carboxamide;

carboxamide; <20> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide;

<21> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chlorobenzo[b]thiophene-2-carboxamide; <22> N-(5-

5 (benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-bromobenzo[b]thiophene-2-carboxamide; <23> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-methylbenzo[b]thiophene-2-carboxamide; <24> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-

10 fluorobenzo[b]thiophene-2-carboxamide; <25> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3,6-dichlorobenzo[b]thiophene-2-carboxamide; <26> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-methoxybenzo[b]thiophene-2-carboxamide; <27> N-(5-

15 hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <28> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1-methyl-1H-indole-2-carboxamide; <29> 7-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <30> 6-chloro-N-(5-hydroxy-3,4,6-

20 trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <31> 6-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <32> 5-fluoro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <33> 5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-

25 yl)-1H-indole-2-carboxamide; <34> 5-chloro-N-(5-

hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <35> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-methyl-1H-indole-2-carboxamide; <36> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-

5 (trifluoromethyl)-1H-indole-2-carboxamide; <37> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethoxy)-1H-indole-2-carboxamide; <38> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-indole-2-carboxamide; <39> N-(5-hydroxy-3,4,6-

10 trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-carboxamide; <40> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide; <41> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide; <42> 5-chloro-N-(5-hydroxy-3,4,6-

15 trimethylpyridin-2-yl)benzofuran-2-carboxamide; <43> 5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide; <44> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-7-methoxybenzofuran-2-carboxamide; <45> N-(5-hydroxy-3,4,6-trimethylpyridin-

20 2-yl)-3-methylbenzofuran-2-carboxamide; <46> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide; <47> 3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide; <48> 3-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-

25 yl)benzo[b]thiophene-2-carboxamide; <49> 3-chloro-N-

(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-
 methylbenzo[b]thiophene-2-carboxamide; <50> 3-chloro-
 6-fluoro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-
 yl)benzo[b]thiophene-2-carboxamide; <51> 3,6-dichloro-
 5 N-(5-hydroxy-3,4,6-trimethylpyridin-2-
 yl)benzo[b]thiophene-2-carboxamide; <52> 3-chloro-N-
 (5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-
 methoxybenzo[b]thiophene-2-carboxamide; <53> 3-chloro-
 6-fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-
 10 yl)benzo[b]thiophene-2-carboxamide; <54> 3-chloro-6-
 fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-yl)-N-
 methylbenzo[b]thiophene-2-carboxamide; <55> 3-chloro-
 6-fluoro-N-(5-(2-(isopropylamino)-2-oxoethoxy)-3,4,6-
 trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide;
 15 <56> 3-chloro-N-(5-(2-(cyclopropylamino)-2-oxoethoxy)-
 3,4,6-trimethylpyridin-2-yl)-6-
 fluorobenzo[b]thiophene-2-carboxamide; <57> 3-chloro-
 N-(5-(2-(cyclohexylamino)-2-oxoethoxy)-3,4,6-
 trimethylpyridin-2-yl)-6-fluorobenzo[b]thiophene-2-
 20 carboxamide; <58> N-(5-(2-(benzylamino)-2-oxoethoxy)-
 3,4,6-trimethylpyridin-2-yl)-3-chloro-6-
 fluorobenzo[b]thiophene-2-carboxamide; <59> 3-chloro-
 6-fluoro-N-(3,4,6-trimethyl-5-(2-oxo-2-
 (phenylamino)ethoxy)pyridin-2-yl)benzo[b]thiophene-2-
 25 carboxamide; <60> 6-(3-chloro-6-

fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl benzoate; <61> 6-(3-chloro-6-
 fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 4-fluorobenzoate; <62> 6-(3-
 5 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 3-methoxybenzoate; <63> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 4-methoxybenzoate; <64> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 10 trimethylpyridin-3-yl 5-fluoropicolinate; <65> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin- 3-yl 6-fluoronicotinate; <66> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 5-chloropicolinate; <67> 6-(3-
 15 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin- 3-yl 6-chloropicolinate; <68> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl (3r,5r,7r)-adamantane-1-
 carboxylate; <69> 6-(3-chloro-6-
 20 fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl morpholine-4-carboxylate.

The compound represented by formula 1 of the
 present invention can be used as a form of a
 25 pharmaceutically acceptable salt, in which the salt is

preferably acid addition salt formed by pharmaceutically acceptable free acids. The acid addition salt herein can be obtained from inorganic acids such as hydrochloric acid, nitric acid, 5 phosphoric acid, sulfuric acid, hydrobromic acid, hydroiodic acid, nitrous acid, and phosphorous acid; non-toxic organic acids such as aliphatic mono/dicarboxylate, phenyl-substituted alkanoate, hydroxy alkanoate, alkandioate, aromatic acids, and 10 aliphatic/aromatic sulfonic acids; or organic acids such as acetic acid, benzoic acid, citric acid, lactic acid, maleic acid, gluconic acid, methanesulfonic acid, 4-toluenesulfonic acid, tartaric acid, and fumaric acid. The pharmaceutically non-toxic salts are 15 exemplified by sulfate, pyrosulfate, bisulfate, sulphite, bisulphite, nitrate, phosphate, monohydrogen phosphate, dihydrogen phosphate, metaphosphate, pyrophosphate, chloride, bromide, iodide, fluoride, acetate, propionate, decanoate, caprylate, acrylate, 20 formate, isobutylate, caprate, heptanoate, propiolate, oxalate, malonate, succinate, suberate, cabacate, fumarate, maliate, butyne-1,4-dioate, hexane-1,6-dioate, benzoate, chlorobenzoate, methylbenzoate, dinitrobenzoate, hydroxybenzoate, methoxybenzoate, 25 phthalate, terephthalate, benzenesulfonate,

toluenesulfonate, chlorobenzenesulfonate,
xylenesulfonate, phenylacetate, phenylpropionate,
phenylbutylate, citrate, lactate, hydroxybutylate,
glycolate, malate, tartrate, methanesulfonate,
5 propanesulfonate, naphthalene-1-sulfonate,
naphthalene-2-sulfonate, and mandelate.

The acid addition salt according to the present invention can be prepared by the conventional method known to those in the art. For example, the derivative
10 represented by formula 1 is dissolved in an organic solvent such as methanol, ethanol, acetone, methylene chloride and acetonitrile, to which organic acid or inorganic acid is added to induce precipitation. Then, the precipitate is filtered and dried to give the
15 salt. Or the solvent and the excessive acid are distilled under reduced pressure, and dried to give the salt. Or the precipitate is crystallized in an organic solvent to give the same.

A pharmaceutically acceptable metal salt can be
20 prepared by using a base. Alkali metal or alkali earth metal salt is obtained by the following processes: dissolving the compound in excessive alkali metal hydroxide or alkali earth metal hydroxide solution; filtering non-soluble compound salt; evaporating the
25 remaining solution and drying thereof. At this time,

the metal salt is preferably prepared in the pharmaceutically suitable form of sodium, potassium, or calcium salt. And the corresponding salt is prepared by the reaction of alkali metal or alkali
5 earth metal salt with proper silver salt (ex; silver nitrate).

In addition, the present invention includes not only the compound represented by formula 1 but also a pharmaceutically acceptable salt thereof, and a
10 solvate, an optical isomer, or a hydrate possibly produced from the same.

The term "hydrate" refers to a compound or a salt thereof of the present invention containing a
15 stoichiometric or non-stoichiometric amount of water bound by a non-covalent intermolecular force. The hydrate of the compound represented by formula 1 of the present invention can contain a stoichiometric or non-stoichiometric amount of water bonded by a non-
20 covalent intermolecular force. The hydrate can contain 1 equivalent or more of water, preferably 1 to 5 equivalents of water. The hydrate can be prepared by crystallizing the compound represented by formula 1, the isomer thereof, or the pharmaceutically acceptable

salt thereof from water or the solvent containing water.

The term "solvate" refers to a compound or a salt
5 thereof of the present invention containing a
stoichiometric or non-stoichiometric amount of solvent
bound by a non-covalent intermolecular force.
Preferred solvents therefor include volatile, non-
toxic, and/or solvents suitable for administration to
10 human.

The term "isomer" refers to a compound or a salt
thereof of the present invention having the same
chemical formula or molecular formula, but
15 structurally or sterically different. Such isomers
include structural isomers such as tautomers, R or S
isomers having an asymmetric carbon center,
stereoisomers such as geometric isomers (trans, cis),
and optical isomers (enantiomers). All these isomers
20 and mixtures thereof are also included in the scope of
the present invention.

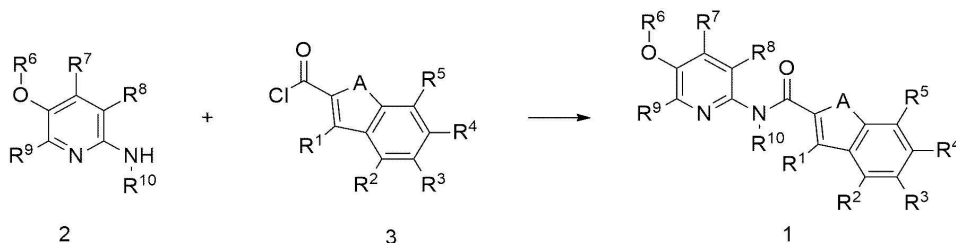
The compound represented by formula 1 of the
present invention can be prepared according to the
25 preparation method shown in reaction formula 1 or

reaction formula 2 below, but this is only an example, and is not limited thereto, and each preparation step can be performed using a method well known to those in the art.

5

The compound represented by formula 1 according to the present invention can be prepared by a method for preparing a compound represented by formula 1 comprising a step of preparing a compound represented by formula 1 by reacting a compound represented by formula 2 with a compound represented by formula 3, as shown in reaction formula 1 below:

[Reaction Formula 1]



15

(In reaction formula 1,

A, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, and R¹⁰ are as defined in formula 1).

As shown in reaction formula 1, amine of the compound represented by formula 2 and Cl of the compound represented by formula 3 react to prepare a

compound represented by Formula 1 in which an amide bond is formed. The above step can be performed using a method well known to those in the art, and the compound can be prepared according to an embodiment of
5 the present invention, but this is only an example and is not limited thereto.

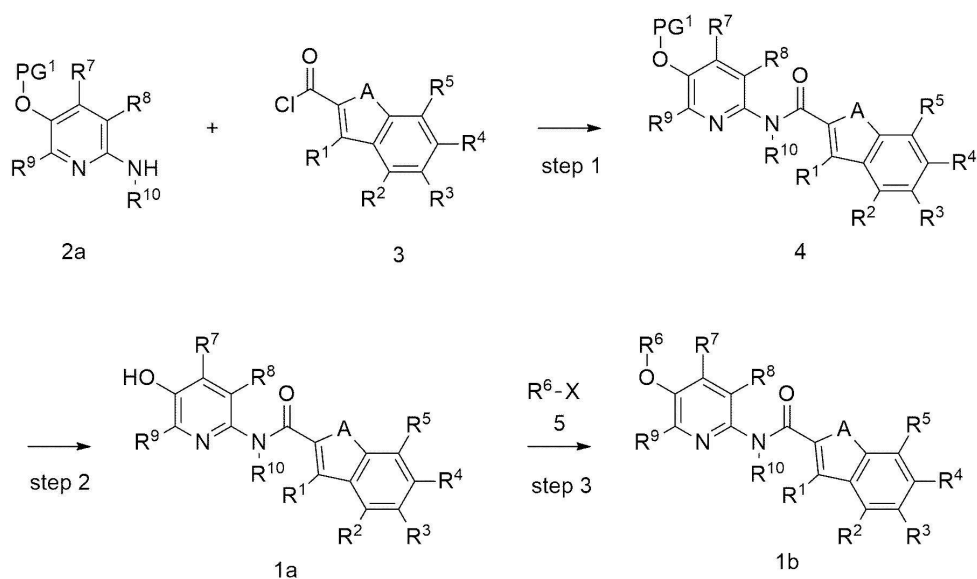
The compound represented by formula 1 according to the present invention can be prepared by a method
10 for preparing a compound represented by formula 1 comprising the following steps, as shown in reaction formula 2 below:

preparing a compound represented by formula 4 by reacting a compound represented by formula 2a with a
15 compound represented by formula 3 (step 1);

preparing a compound represented by formula 1a by deprotecting the compound represented by formula 4 obtained in step 1 above (step 2); and

preparing a compound represented by formula 1b by
20 reacting the compound represented by formula 1a obtained in step 2 above with a compound represented by formula 5 (step 3):

[Reaction Formula 2]



(In reaction formula 2,

A, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, and R¹⁰ are as defined in formula 1 except when R⁶ is hydrogen;

the compound represented by formula 1a is a derivative of formula 1 wherein R⁶ is hydrogen;

the compound represented by formula 1b is a derivative of formula 1 except when R⁶ is hydrogen;

PG¹ is an alcohol protecting group selected from the group consisting of acetyl (Ac), benzoyl (Bz), benzyl (Bn), methylthiomethyl ether, MEM (β-methoxyethoxymethyl ether), DMT (dimethoxytrityl, [bis-(4-methoxyphenyl)phenylmethyl]), MOM (methoxymethyl ether), MMT (methoxytrityl [(4-methoxyphenyl)diphenylmethyl]), PMP (p-methoxybenzyl ether), Piv (pivaloyl), THP (tetrahydropyranyl), THF

(tetrahydrofuran) and Trityl (triphenylmethyl, Tr);
and

X is halogen).

5 As shown in step 1 of reaction formula 2, amine
of the compound represented by formula 2a and Cl of
the compound represented by formula 3 react to prepare
a compound represented by Formula 4 in which an amide
bond is formed. The above step can be performed using
10 a method well known to those in the art, and the
compound can be prepared according to an embodiment of
the present invention, but this is only an example and
is not limited thereto.

Step 2 of reaction formula 2 is a step of
15 preparing an alcohol compound represented by formula
1a by removing an alcohol protecting group of the
compound represented by formula 4. The step can be
performed according to a known method capable of
removing the alcohol protecting group, and those
20 skilled in the art can easily select and proceed under
what conditions the removal reaction can be performed
according to the type of the protecting group. The
compound can be prepared according to an embodiment of
the present invention, but this is only an example and
25 is not limited thereto.

Step 3 of Scheme 2 is a step of preparing a compound represented by formula 1b by reacting hydroxyl of the compound represented by formula 1a with halide of the compound represented by formula 4.

5 The above step can be performed using a method well known to those in the art, and the compound can be prepared according to an embodiment of the present invention, but this is only an example and is not limited thereto.

10

In another aspect of the present invention, the present invention provides a pharmaceutical composition comprising a compound represented by formula 1, an isomer thereof, a solvate thereof, a
15 hydrate thereof, or a pharmaceutically acceptable salt thereof as an active ingredient for the prevention or treatment of autoimmune disease.

The compound may inhibit the adhesion of monocytes to intestinal epithelial cells by TNF- α or
20 IL-6.

The autoimmune disease can be at least one selected from the group consisting of inflammatory bowel disease, asthma, type 1 diabetes, rheumatoid arthritis, polymyalgia rheumatica, ankylosing
25 spondylitis, psoriatic arthritis, psoriasis, eczema,

sclerosis, vitiligo, multiple sclerosis, IL-17-induced
dementia, peripheral neuritis, uveitis,
polymyositis/dermatomyositis, autoimmune cytopenia,
autoimmune myocarditis, atopic dermatitis, primary
5 cirrhosis, dry eye syndrome, fibromyalgia,
Goodpasture's syndrome, autoimmune meningitis,
Sjogren's syndrome, systemic lupus erythematosus,
Addison's disease, alopecia areata, autoimmune
hepatitis, autoimmune mumps, dystrophic epidermolysis
10 bullosa, epididymitis, glomerulonephritis, Graves'
disease, celiac disease, Guillain-Barré syndrome,
Hashimoto's disease, hemolytic anemia, myasthenia
gravis, amyotrophic lateral sclerosis, pemphigus
vulgaris, rheumatic fever, sarcoidosis, skin
15 sclerosis, spondyloarthritis, thyroiditis, vasculitis,
vitiligo, myxedema, pernicious anemia,
antiphospholipid syndrome, late and chronic rejection
of solid organ transplantation, and graft-versus-host
disease.

20 The inflammatory bowel disease can be any one
selected from the group consisting of enteritis,
colitis, ulcerative enteritis, Crohn's disease,
Crohn's cytoma, irritable bowel syndrome, hemorrhagic
rectal ulcer, pouchitis, peptic ulcer, intestinal
25 Behcet's disease and gastritis.

In the pharmaceutical composition according to the present invention, the compound represented by formula 1 or the pharmaceutically acceptable salt thereof can be administered orally or parenterally, preferably parenterally, and be used in general forms of pharmaceutical formulation. That is, the compound or the pharmaceutically acceptable salt thereof can be prepared for oral or parenteral administration by mixing with generally used diluents or excipients such as fillers, extenders, binders, wetting agents, disintegrating agents and surfactants. Solid formulations for oral administration are tablets, pills, powders, granules and capsules. These solid formulations are prepared by mixing one or more compounds with one or more suitable excipients such as starch, calcium carbonate, sucrose or lactose, gelatin, etc. Except for the simple excipients, lubricants, for example magnesium stearate, talc, etc, can be used. Liquid formulations for oral administrations are suspensions, solutions, emulsions and syrups, and the above-mentioned formulations can contain various excipients such as wetting agents, sweeteners, aromatics and preservatives in addition to generally used simple diluents such as water and

liquid paraffin. Formulations for parenteral administration are sterilized aqueous solutions, water-insoluble excipients, suspensions and emulsions. Water insoluble excipients and suspensions can
5 contain, in addition to the active compound or compounds, propylene glycol, polyethylene glycol, vegetable oil like olive oil, injectable ester like ethylolate, etc.

10 The pharmaceutical composition comprising the compound represented by formula 1 or the pharmaceutically acceptable salt thereof as an active ingredient can be administered by parenterally and the parenteral administration includes subcutaneous
15 injection, intravenous injection, intramuscular injection, or intrathoracic injection.

At this time, to prepare the compound represented by formula 1 or the pharmaceutically acceptable salt thereof as a formulation for parenteral
20 administration, the compound represented by formula 1 or the pharmaceutically acceptable salt thereof is mixed with a stabilizer or a buffering agent in water to produce a solution or suspension, which is then formulated as ampoules or vials. The composition
25 herein can be sterilized and additionally contains

preservatives, stabilizers, wettable powders or emulsifiers, salts and/or buffers for the regulation of osmotic pressure, and other therapeutically useful materials, and the composition can be formulated by
5 the conventional mixing, granulating or coating method.

The formulations for oral administration are exemplified by tablets, pills, hard/soft capsules,
10 solutions, suspensions, emulsions, syrups, granules, elixirs, and troches, etc. These formulations can include diluents (for example: lactose, dextrose, sucrose, mannitol, sorbitol, cellulose and/or glycine) and lubricants (for example: silica, talc, stearate
15 and its magnesium or calcium salt and/or polyethylene glycol) in addition to the active ingredient. Tablets can include binding agents such as magnesium aluminum silicate, starch paste, gelatin, methylcellulose, sodium carboxymethylcellulose and/or
20 polyvinylpyrrolidone, and if necessary disintegrating agents such as starch, agarose, alginic acid or its sodium salt or azeotropic mixtures and/or absorbents, coloring agents, flavours, and sweeteners can be additionally included thereto.

25

In another aspect of the present invention, the present invention provides a health functional food comprising a compound represented by formula 1, an isomer thereof, a solvate thereof, a hydrate thereof
5 or a pharmaceutically acceptable salt thereof as an active ingredient for the prevention or amelioration of autoimmune disease.

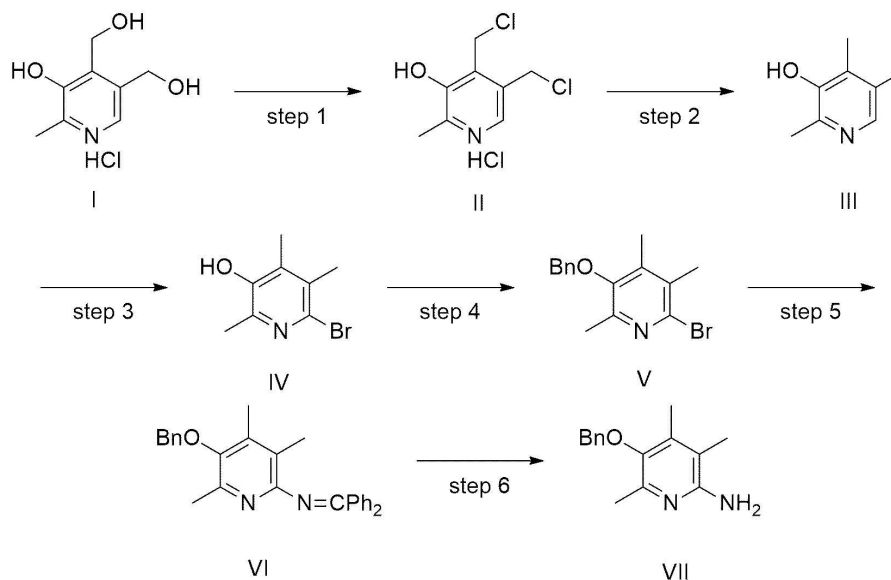
In another aspect of the present invention, the present invention provides a method for preventing or
10 treating autoimmune disease, which comprises a step of administering a pharmaceutical composition or a health functional food comprising a compound represented by formula 1, an isomer thereof, a solvate thereof, a hydrate thereof or a pharmaceutically acceptable salt
15 thereof as an active ingredient to a subject in need.

In another aspect of the present invention, the present invention provides a use of the pharmaceutical composition or the health functional food above comprising a compound represented by formula 1, an
20 isomer thereof, a solvate thereof, a hydrate thereof or a pharmaceutically acceptable salt thereof as an active ingredient for the prevention or treatment of autoimmune disease.

Hereinafter, the present invention will be described in detail by the following examples and experimental examples.

However, the following examples and experimental
5 examples are only for illustrating the present invention, and the contents of the present invention are not limited thereto.

<Preparative Example 1> Preparation of 5-(benzyloxy)-3,4,6-trimethylpyridin-2-amine
10



Step 1: Synthesis of 4,5-bis(chloromethyl)-2-methylpyridin-3-ol hydrochloride (Formula II)

SOCl₂ (15 mL) and DMF (0.38 mL) were added to
15 pyridoxinehydrochloride (Formula I) (10 g), and the mixture was stirred at 80°C for 30 minutes. The

reaction mixture was cooled to room temperature, to which Et₂O (140 mL) was added, and the mixture was stirred under ice cooling for 1 hour. The precipitated solid in the reaction solution was filtered under
5 reduced pressure, and the filtered solid was washed with Et₂O and dried to give the target compound II (11.3 g) as a white solid.

¹H-NMR ((CD₃)₂SO) δ 8.42 (s, 1H), 4.99 (s, 2H), 4.96 (s, 2H), 2.63 (s, 3H).

10

Step 2: Synthesis of 2,4,5-trimethylpyridin-3-ol (Formula III)

Zinc powder (8.08 g) was added in small portions to the acetic acid (50 mL) suspension of compound II
15 (10 g) several times, and the mixture was stirred under reflux at 130°C for 2 hours. The reaction mixture was cooled to room temperature, and the solid in the reaction solution was removed by filtration under reduced pressure. Then, the pH of the filtrate
20 was adjusted to 6 using 10 M NaOH solution. The filtrate was saturated with salt and then extracted several times with EtOAc. The extract was washed with saturated brine, dried over anhydrous MgSO₄, filtered, and concentrated under reduced pressure. The residue
25 was purified by column chromatography

(CHCl₃:MeOH=20:1) to give the target compound III (5.2 g) as a white solid.

¹H-NMR ((CD₃)₂SO) δ 8.49 (s, 1H), 7.72 (s, 1H), 2.31 (s, 3H), 2.12 (s, 3H), 2.08 (s, 3H).

5

Step 3: Synthesis of 6-bromo-2,4,5-trimethylpyridin-3-ol (Formula IV)

1,3-Dibromo-5,5-dimethylhydantoin (DBDMH, 2.5 g) was added to the THF suspension (30 mL) of Compound III (2.5 g), followed by stirring at room temperature for 3 hours. After the reaction mixture was concentrated, the residue was diluted with EtOAc and water, and the aqueous layer was extracted with EtOAc. The EtOAc solution was washed with saturated brine, dried over anhydrous MgSO₄, filtered, and concentrated under reduced pressure. The residue was purified by column chromatography (EtOAc:Hexanes=1:4) to give the target compound IV (3.22 g) as a pale yellow solid.

¹H-NMR (CDCl₃) δ 5.56 (br s, 1H), 2.42 (s, 3H), 2.31 (s, 3H), 2.25 (s, 3H).

Step 4: Synthesis of 3-(benzyloxy)-6-bromo-2,4,5-trimethylpyridine (Formula V)

K₂CO₃ (20.78 g) and benzyl chloride (5.2 mL) were sequentially added to a DMF solution (15 mL) of

compound IV (6.5 g), followed by stirring at room temperature for 12 hours. The reaction solution was diluted with EtOAc and washed several times with a small amount of water. The EtOAc solution was washed
5 with saturated brine, dried over anhydrous MgSO_4 , filtered, and concentrated under reduced pressure. The residue was purified by column chromatography (EtOAc:Hexanes=1:20) to give the target compound V (8.9 g) as a white solid.

10 $^1\text{H-NMR}$ (CDCl_3) δ 7.38–7.43 (m, 5H), 4.77 (s, 2H), 2.46 (s, 3H), 2.32 (s, 3H), 2.24 (s, 3H).

Step 5: Synthesis of 5-(benzyloxy)-N-(diphenylmethylene)-3,4,6-trimethylpyridin-2-amine
15 (Formula VI)

Benzophenoneimine (1.73 mL) was added to a toluene (30 mL) solution of compound V (3 g), tris(dibenzylideneacetone)dipalladium(0) (203 mg), 2,2'-bis(diphenylphosphino)-1,1'-binaphthyl (249 mg)
20 and NaO^tBu (1.36 g), and the mixture was stirred under reflux for 12 hours. The reaction solution was cooled to room temperature, and diluted with EtOAc and water. The EtOAc solution was washed several times with saturated brine, dried over anhydrous MgSO_4 , filtered,
25 and concentrated under reduced pressure. The residue

was purified by column chromatography (EtOAc:Hexanes=1:4) to give the target compound VI (3.28 g) as a yellow solid.

¹H-NMR (CDCl₃) δ 7.80 (d, J=7.1 Hz, 2H), 7.17-7.48
5 (m, 13H), 4.69 (s, 2H), 2.29 (s, 3H), 2.03 (s, 3H),
1.91 (s, 3H).

Step 6: Synthesis of 5-(benzyloxy)-3,4,6-trimethylpyridin-2-amine (Formula VII)

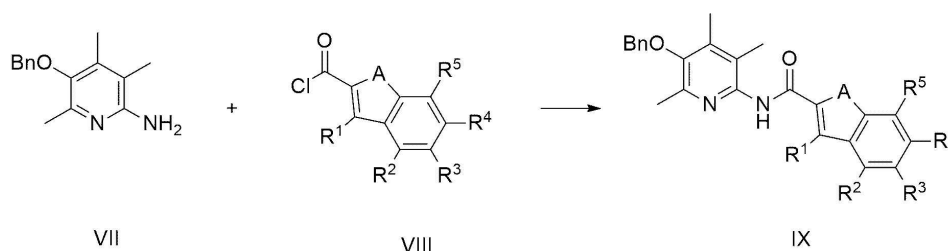
10 A solution in which acetyl chloride (3.2 mL) was added little by little to methanol (20 mL) under ice cooling was added to a methanol (60 mL)-THF (20 mL) mixed solution of compound VI (7.7 g), followed by stirring at room temperature for 12 hours. After the
15 reaction solution was concentrated under reduced pressure, the residue was diluted with EtOAc and washed several times with saturated sodium hydrogen carbonate solution. The EtOAc solution was washed with saturated brine, dried over anhydrous MgSO₄, filtered,
20 and concentrated under reduced pressure. The residue was purified by column chromatography (CHCl₃:MeOH=20:1) to give the target compound VII (4.36 g) as a pale yellow solid.

$^1\text{H-NMR}$ (CDCl_3) δ 7.31–7.45 (m, 5H), 4.68 (s, 2H), 4.25 (br s, 1H), 2.34 (s, 3H), 2.16 (s, 3H), 1.99 (s, 3H).

5 **<General preparation procedure 1 of examples>**

According to the preparation method of reaction formula A, the compounds of examples 1-26 (Compounds IX-01 ~ IX-26) were prepared.

[Reaction Formula A]



10

In reaction formula A above,

A, R^1 , R^2 , R^3 , R^4 and R^5 are as defined in this specification.

Particularly, compound VIII (1.5~2.0 mmol) and
 15 Et_3N (2.0 mmol) were sequentially added to a CH_2Cl_2 (or
 $\text{ClCH}_2\text{CH}_2\text{Cl}$, 10 mL) solution of compound VII (1.0 mmol)
 at room temperature, and the reaction mixture was
 stirred at room temperature ~ 60°C until the compound
 VII disappeared on TLC. The reaction mixture was
 20 diluted with CH_2Cl_2 and washed with saturated NaHCO_3
 aqueous solution. The CH_2Cl_2 solution was dried over

anhydrous MgSO_4 , filtered, concentrated under reduced pressure, and the residue was purified by silica gel column chromatography to give compounds IX-01 to IX-26.

5

<Example 1> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide (Formula IX-01)

The target compound was prepared according to the
10 method of general preparation procedure 1 of examples.

$^1\text{H-NMR}$ (CDCl_3) δ 9.69 (s, 1H), 8.75 (s, 1H), 7.67 (d, $J = 7.9$ Hz, 1H), 7.52-7.27 (m, 7H), 7.19-7.08 (m, 2H), 4.80 (s, 2H), 2.47 (s, 3H), 2.31 (s, 3H), 2.23 (s, 3H).

15

<Example 2> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-1-methyl-1H-indole-2-carboxamide (Formula IX-02)

The target compound was prepared according to the
20 method of general preparation procedure 1 of examples.

$^1\text{H-NMR}$ (CDCl_3) δ 8.34 (s, 1H), 7.68 (d, $J = 8.0$ Hz, 1H), 7.51-7.32 (m, 7H), 7.15 (d, $J = 0.5$ Hz, 2H), 4.80 (s, 2H), 4.06 (s, 3H), 2.47 (s, 3H), 2.30 (s, 3H), 2.23 (s, 3H).

25

<Example 3> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-7-bromo-1H-indole-2-carboxamide (Formula IX-03)

The target compound was prepared according to the
5 method of general preparation procedure 1 of examples.

$^1\text{H-NMR}$ (CDCl_3) δ 9.45 (s, 2H), 7.60 (d, J = 8.0 Hz, 1H), 7.51-7.33 (m, 6H), 7.21 (s, 1H), 7.04 (d, J = 7.8 Hz, 1H), 4.77 (s, 2H), 2.45 (s, 3H), 2.26 (s, 3H), 2.22 (s, 3H).

10

<Example 4> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-chloro-1H-indole-2-carboxamide (Formula IX-04)

The target compound was prepared according to the
15 method of general preparation procedure 1 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 11.84 (s, 1H), 10.51 (s, 1H), 7.69 (d, J = 8.5 Hz, 1H), 7.56-7.35 (m, 7H), 7.08 (dd, J = 8.5, 1.9 Hz, 1H), 4.85 (s, 2H), 2.40 (s, 3H), 2.26 (s, 3H), 2.08 (s, 3H).

20

<Example 5> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-bromo-1H-indole-2-carboxamide (Formula IX-05)

The target compound was prepared according to the
25 method of general preparation procedure 1 of examples.

¹H-NMR ((CD₃)₂SO) δ 11.84 (s, 1H), 10.52 (s, 1H), 7.65 (d, J = 10.3 Hz, 2H), 7.58-7.35 (m, 6H), 7.20 (dd, J = 8.4, 1.2 Hz, 1H), 4.86 (s, 2H), 2.40 (s, 3H), 2.27 (s, 3H), 2.09 (s, 3H).

5

<Example 6> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-fluoro-1H-indole-2-carboxamide (Formula IX-06)

The target compound was prepared according to the
10 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 9.66 (s, 1H), 8.64 (s, 1H), 7.52-7.37 (m, 5H), 7.30 (dd, J = 6.6, 2.8 Hz, 2H), 7.09-6.99 (m, 2H), 4.81 (s, 2H), 2.46 (s, 3H), 2.30 (s, 3H), 2.22 (s, 3H).

15

<Example 7> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromo-1H-indole-2-carboxamide (Formula IX-07)

The target compound was prepared according to the
20 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 9.93 (s, 1H), 7.80 (d, J = 1.7 Hz, 1H), 7.50-7.37 (m, 6H), 7.35 (d, J = 1.8 Hz, 1H), 7.30 (s, 1H), 7.06 (d, J = 1.4 Hz, 1H), 4.75 (s, 2H), 2.48 (s, 3H), 2.21 (d, J = 8.1 Hz, 6H).

25

<Example 8> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chloro-1H-indole-2-carboxamide (Formula IX-08)

The target compound was prepared according to the
5 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 10.25 (s, 1H), 9.18 (dd, *J* = 5.2, 2.9 Hz, 1H), 7.58 (s, 1H), 7.43 (dd, *J* = 11.2, 5.4 Hz, 5H), 7.19 (d, *J* = 2.6 Hz, 2H), 7.02 (s, 1H), 4.81 (s, 2H), 2.45 (s, 3H), 2.30 (s, 3H), 2.23 (s, 3H).

10

<Example 9> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methyl-1H-indole-2-carboxamide (Formula IX-09)

The target compound was prepared according to the
15 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 12.72 (s, 1H), 11.04 (s, 1H), 10.37 (s, 1H), 7.84 (s, 1H), 7.55-7.35 (m, 7H), 7.20 (d, *J* = 8.4 Hz, 1H), 4.84 (s, 2H), 2.55 (s, 3H), 2.52 (s, 3H), 2.31 (s, 3H), 2.25 (s, 3H).

20

<Example 10> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethyl)-1H-indole-2-carboxamide (Formula IX-10)

The target compound was prepared according to the
25 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 10.26 (s, 1H), 9.16 (s, 1H), 7.94 (s, 1H), 7.53-7.33 (m, 7H), 7.17 (d, J = 1.3 Hz, 1H), 4.83 (s, 2H), 2.46 (s, 3H), 2.32 (s, 3H), 2.24 (s, 3H).

5

<Example 11> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethoxy)-1H-indole-2-carboxamide (Formula IX-11)

The target compound was prepared according to the
10 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 10.06 (s, 1H), 9.03 (s, 1H), 7.53-7.28 (m, 7H), 7.12 (d, J = 11.8 Hz, 2H), 4.82 (s, 2H), 2.46 (s, 3H), 2.31 (s, 3H), 2.23 (s, 3H).

15 <Example 12> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-indole-2-carboxamide (Formula IX-12)

The target compound was prepared according to the
method of general preparation procedure 1 of examples.

20 ¹H-NMR (CDCl₃) δ 9.54 (s, 1H), 8.76-8.54 (m, 1H), 7.56-7.35 (m, 6H), 7.03 (d, J = 1.8 Hz, 1H), 6.81 (dd, J = 4.6, 2.4 Hz, 2H), 4.79 (s, 2H), 3.83 (s, 3H), 2.45 (s, 3H), 2.28 (s, 3H), 2.22 (s, 3H).

<Example 13> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-carboxamide (Formula IX-13)

The target compound was prepared according to the
5 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 9.72 (s, 1H), 9.24-8.76 (m, 1H), 7.54-7.33 (m, 5H), 7.23 (s, 1H), 7.04 (s, 2H), 6.98-6.89 (m, 1H), 4.78 (s, 2H), 3.83 (s, 3H), 2.46 (s, 3H), 2.28 (s, 3H), 2.22 (s, 3H).

10

<Example 14> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide (Formula IX-14)

The target compound was prepared according to the
15 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 9.57 (s, 1H), 7.41 (dd, *J* = 8.6, 3.9 Hz, 5H), 7.02 (s, 2H), 6.84 (s, 1H), 4.73 (s, 2H), 3.91 (s, 6H), 2.47 (s, 3H), 2.22 (d, *J* = 4.8 Hz, 6H).

20 <Example 15> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide (Formula IX-15)

The target compound was prepared according to the method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 8.60 (s, 1H), 7.70 (d, J = 7.7 Hz, 1H), 7.59 (d, J = 0.8 Hz, 1H), 7.57-7.28 (m, 8H), 4.81 (s, 2H), 2.47 (s, 3H), 2.30 (s, 3H), 2.23 (s, 3H).

5

<Example 16> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chlorobenzofuran-2-carboxamide (Formula IX-16)

The target compound was prepared according to the
10 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 8.64 (s, 1H), 7.70-7.64 (m, 1H), 7.52 (d, J = 0.8 Hz, 1H), 7.50-7.36 (m, 7H), 4.81 (s, 2H), 2.46 (s, 3H), 2.30 (s, 3H), 2.22 (s, 3H).

15 <Example 17> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromobenzofuran-2-carboxamide (Formula IX-17)

[N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromobenzofuran-2-carboxamide]

20 The target compound was prepared according to the method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 8.70 (s, 1H), 7.85 (d, J = 1.9 Hz, 1H), 7.54 (d, J = 3.3 Hz, 2H), 7.50-7.38 (m, 6H), 4.81 (s, 2H), 2.47 (s, 3H), 2.31 (s, 3H), 2.22 (s,
25 3H).

<Example 18> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-7-methoxybenzofuran-2-carboxamide (Formula IX-18)

5 The target compound was prepared according to the method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 8.98 (s, 1H), 7.66-7.59 (m, 1H), 7.51-7.33 (m, 5H), 7.25-7.22 (m, 2H), 6.94 (dd, J = 7.3, 1.6 Hz, 1H), 4.81 (s, 2H), 4.03 (s, 3H), 2.49 (s,
10 3H), 2.31 (d, J = 2.3 Hz, 3H), 2.22 (s, 3H).

<Example 19> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-methylbenzofuran-2-carboxamide (Formula IX-19)

15 The target compound was prepared according to the method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 8.59 (s, 1H), 7.63 (d, J = 7.9 Hz, 1H), 7.56-7.27 (m, 8H), 4.81 (s, 2H), 2.64 (s, 3H), 2.48 (s, 3H), 2.27 (d, J = 10.2 Hz, 6H).

20

<Example 20> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula IX-20)

The target compound was prepared according to the
25 method of general preparation procedure 1 of examples.

^1H -NMR (CDCl_3) δ 8.69 (s, 1H), 7.97 (s, 1H), 7.90-7.82 (m, 2H), 7.51-7.35 (m, 7H), 4.80 (s, 2H), 2.44 (s, 3H), 2.29 (s, 3H), 2.23 (s, 3H).

5 <Example 21> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chlorobenzo[b]thiophene-2-carboxamide (Formula IX-21)

The target compound was prepared according to the method of general preparation procedure 1 of examples.

10 ^1H -NMR (CDCl_3) δ 8.87 (s, 1H), 7.97-7.90 (m, 1H), 7.85 (dt, J = 5.2, 3.3 Hz, 1H), 7.54-7.39 (m, 7H), 4.81 (s, 2H), 2.48 (s, 3H), 2.29 (s, 3H), 2.24 (s, 3H).

15 <Example 22> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-bromobenzo[b]thiophene-2-carboxamide (Formula IX-22)

The target compound was prepared according to the method of general preparation procedure 1 of examples.

20 ^1H -NMR (CDCl_3) δ 8.89 (s, 1H), 7.97-7.82 (m, 2H), 7.56-7.38 (m, 7H), 4.81 (s, 2H), 2.47 (s, 3H), 2.30 (s, 3H), 2.25 (s, 3H).

<Example 23> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-methylbenzo[b]thiophene-2-carboxamide (Formula IX-23)

The target compound was prepared according to the
5 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 10.27 (s, 1H), 8.65 (s, 1H), 8.34 (d, J = 1.6 Hz, 1H), 7.91 (d, J = 8.7 Hz, 1H), 7.63 (dd, J = 8.7, 1.9 Hz, 1H), 2.32 (s, 3H), 2.18 (s, 3H), 2.10 (s, 3H).

10

<Example 24> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-fluorobenzo[b]thiophene-2-carboxamide (Formula IX-24)

The target compound was prepared according to the
15 method of general preparation procedure 1 of examples.

¹H-NMR (CDCl₃) δ 8.84 (s, 1H), 7.89 (dd, J = 9.0, 5.0 Hz, 1H), 7.58-7.50 (m, 1H), 7.49-7.33 (m, 5H), 7.32-7.27 (m, 1H), 4.81 (s, 2H), 2.47 (s, 3H), 2.30 (s, 3H), 2.24 (s, 3H).

20

<Example 25> Synthesis of N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3,6-dichlorobenzo[b]thiophene-2-carboxamide (Formula IX-25)

The target compound was prepared according to the
25 method of general preparation procedure 1 of examples.

In reaction formula B above,

A, R¹, R², R³, R⁴ and R⁵ are as defined in this specification.

Pentamethylbenzene (3.0 mmol) was added to a
5 CH₂Cl₂ (10 mL) of compound IX (1.0 mmol), and the
reaction solution was cooled with ice. A CH₂Cl₂
solution (2.0 mmol) of 1 M BCl₃ was slowly added
thereto, and the reaction mixture was stirred under
ice cooling until the compound IX disappeared on TLC.
10 To the reaction solution, 10 mL of a 9:1 mixed
solution of CHCl₃ and MeOH was added, stirred at room
temperature for 30 minutes, and then concentrated
under reduced pressure. The residue was purified by
silica gel column chromatography to give compounds X-
15 01 ~ X-26.

<Example 27> Synthesis of N-(5-hydroxy-3,4,6-
trimethylpyridin-2-yl)-1H-indole-2-carboxamide
(Formula X-01)

20 The target compound was prepared according to the
method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 11.64 (s, 1H), 10.24 (s, 1H),
8.60 (s, 1H), 7.64 (d, J = 8.0 Hz, 1H), 7.45 (d, J =
8.2 Hz, 1H), 7.36 (d, J = 1.4 Hz, 1H), 7.31-7.13 (m,

1H), 7.10-6.99 (m, 1H), 2.35 (s, 3H), 2.18 (s, 3H),
2.05 (s, 3H).

<Example 28> Synthesis of N-(5-hydroxy-3,4,6-
5 trimethylpyridin-2-yl)-1-methyl-1H-indole-2-
carboxamide (Formula X-02)

The target compound was prepared according to the
method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.18 (s, 1H), 8.56 (s, 1H),
10 7.67 (d, J = 7.9 Hz, 1H), 7.55 (d, J = 8.4 Hz, 1H),
7.34-7.25 (m, 2H), 7.13 (dd, J = 11.0, 3.9 Hz, 1H),
4.00 (s, 3H), 2.35 (s, 3H), 2.18 (s, 3H), 2.07 (s,
3H).

15 <Example 29> Synthesis of 7-bromo-N-(5-hydroxy-
3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide
(Formula X-03)

The target compound was prepared according to the
method of general preparation procedure 2 of examples.

20 ¹H-NMR ((CD₃)₂SO) δ 11.62 (s, 1H), 10.64 (d, J =
0.8 Hz, 1H), 9.09-8.86 (m, 1H), 7.70 (d, J = 7.9 Hz,
1H), 7.46 (dd, J = 14.5, 4.5 Hz, 2H), 7.04 (t, J = 7.8
Hz, 1H), 2.39 (s, 3H), 2.22 (s, 3H), 2.09 (s, 3H).

<Example 30> Synthesis of 6-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide (Formula X-04)

The target compound was prepared according to the method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 11.83 (s, 1H), 10.36 (s, 1H), 8.65 (s, 1H), 7.68 (d, $J = 8.5$ Hz, 1H), 7.42 (d, $J = 14.2$ Hz, 2H), 7.07 (dd, $J = 8.5, 1.6$ Hz, 1H), 2.34 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H).

10

<Example 31> Synthesis of 6-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide (Formula X-05)

The target compound was prepared according to the method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 11.79 (s, 1H), 10.32 (s, 1H), 8.62 (s, 1H), 7.63 (d, $J = 8.7$ Hz, 2H), 7.38 (d, $J = 1.3$ Hz, 1H), 7.18 (dd, $J = 8.5, 1.8$ Hz, 1H), 2.35 (s, 3H), 2.18 (s, 3H), 2.04 (s, 3H).

20

<Example 32> Synthesis of 5-fluoro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide (Formula X-06)

The target compound was prepared according to the method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 11.77 (s, 1H), 10.30 (s, 1H), 8.62 (s, 1H), 7.43 (dt, J = 6.6, 3.0 Hz, 2H), 7.35 (d, J = 1.5 Hz, 1H), 7.07 (td, J = 9.4, 2.5 Hz, 1H), 2.35 (s, 3H), 2.18 (s, 3H), 2.04 (s, 3H).

5

<Example 33> Synthesis of 5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide (Formula X-07)

The target compound was prepared according to the
10 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 11.85 (s, 1H), 10.31 (s, 1H), 8.61 (s, 1H), 7.87 (d, J = 1.2 Hz, 1H), 7.35 (dd, J = 9.5, 7.8 Hz, 3H), 2.35 (s, 3H), 2.18 (s, 3H), 2.05 (s, 3H).

15

<Example 34> Synthesis of 5-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide (Formula X-08)

The target compound was prepared according to the
20 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 11.90 (s, 1H), 10.37 (s, 1H), 8.67 (s, 1H), 7.73 (d, J = 1.8 Hz, 1H), 7.44 (d, J = 8.8 Hz, 1H), 7.35 (s, 1H), 7.20 (dd, J = 8.8, 2.0 Hz, 1H), 2.34 (s, 3H), 2.17 (s, 3H), 2.04 (s, 3H).

25

<Example 35> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-methyl-1H-indole-2-carboxamide (Formula X-09)

The target compound was prepared according to the
5 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 11.54 (d, J = 1.1 Hz, 1H),
10.22 (s, 1H), 8.63 (s, 1H), 7.41 (s, 1H), 7.30 (dd, J
= 12.6, 4.9 Hz, 2H), 7.03 (dd, J = 8.4, 1.4 Hz, 1H),
2.36 (d, J = 8.1 Hz, 6H), 2.17 (s, 3H), 2.04 (s, 3H).

10

<Example 36> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethyl)-1H-indole-2-carboxamide (Formula X-10)

The target compound was prepared according to the
15 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 12.13 (s, 1H), 10.44 (s, 1H),
8.64 (s, 1H), 8.10 (s, 1H), 7.62 (d, J = 8.7 Hz, 1H),
7.59-7.44 (m, 2H), 2.35 (s, 3H), 2.18 (s, 3H), 2.05
(s, 3H).

20

<Example 37> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethoxy)-1H-indole-2-carboxamide (Formula X-11)

The target compound was prepared according to the
25 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 12.08 (s, 1H), 10.74 (s, 1H),
9.31 (s, 1H), 7.71 (s, 1H), 7.53 (d, J = 9.2 Hz, 2H),
7.21 (d, J = 8.8 Hz, 1H), 2.44 (s, 3H), 2.26 (s, 3H),
2.11 (s, 3H).

5

<Example 38> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-indole-2-carboxamide (Formula X-12)

The target compound was prepared according to the
10 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 11.42 (s, 1H), 10.07 (s, 1H),
8.54 (s, 1H), 7.51 (d, J = 8.7 Hz, 1H), 7.28 (s, 1H),
6.90 (s, 1H), 6.71 (dd, J = 8.7, 2.3 Hz, 1H), 3.78 (s,
3H), 2.34 (s, 3H), 2.18 (s, 3H), 2.04 (s, 3H).

15

<Example 39> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-carboxamide (Formula X-13)

The target compound was prepared according to the
20 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 11.85 (s, 1H), 10.31 (s, 1H),
8.61 (s, 1H), 7.87 (d, J = 1.2 Hz, 1H), 7.35 (dd, J =
9.5, 7.8 Hz, 3H), 2.35 (s, 3H), 2.18 (s, 3H), 2.05 (s,
3H).

25

<Example 40> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide (Formula X-14)

The target compound was prepared according to the
5 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 11.33 (s, 1H), 10.04 (s, 1H), 8.55 (s, 1H), 7.24 (d, $J = 1.7$ Hz, 1H), 7.09 (s, 1H), 6.90 (s, 1H), 3.77 (s, 6H), 2.34 (s, 3H), 2.17 (s, 3H), 2.04 (s, 3H).

10

<Example 41> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide (Formula X-15)

The target compound was prepared according to the
15 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.44 (s, 1H), 8.66 (s, 1H), 7.81 (d, $J = 7.7$ Hz, 1H), 7.76-7.65 (m, 2H), 7.53-7.45 (m, 1H), 7.35 (t, $J = 7.5$ Hz, 1H), 2.34 (s, 3H), 2.17 (s, 3H), 2.04 (s, 3H).

20

<Example 42> Synthesis of 5-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide (Formula X-16)

The target compound was prepared according to the
25 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.75 (s, 1H), 9.28-9.04 (m, 1H), 7.93 (d, J = 2.2 Hz, 1H), 7.75 (d, J = 9.2 Hz, 2H), 7.53 (dd, J = 8.7, 2.2 Hz, 2H), 2.41 (s, 3H), 2.24 (s, 3H), 2.10 (s, 3H).

5

<Example 43> Synthesis of 5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide (Formula X-17)

The target compound was prepared according to the
10 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.44 (s, 1H), 8.66 (s, 1H), 7.81 (d, J = 7.7 Hz, 1H), 7.76-7.65 (m, 2H), 7.53-7.45 (m, 1H), 7.35 (t, J = 7.5 Hz, 1H), 2.34 (s, 3H), 2.17 (s, 3H), 2.04 (s, 3H).

15

<Example 44> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-7-methoxybenzofuran-2-carboxamide (Formula X-18)

The target compound was prepared according to the
20 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.53 (s, 1H), 8.90 (d, J = 2.5 Hz, 1H), 7.76 (s, 1H), 7.40-7.22 (m, 2H), 7.09 (d, J = 7.6 Hz, 1H), 3.98 (s, 3H), 2.37 (s, 3H), 2.20 (s, 3H), 2.07 (s, 3H).

25

<Example 45> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-3-methylbenzofuran-2-carboxamide (Formula X-19)

The target compound was prepared according to the
5 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.10 (s, 1H), 8.58 (s, 1H),
7.77 (d, J = 7.7 Hz, 1H), 7.62 (d, J = 8.2 Hz, 1H),
7.55-7.46 (m, 1H), 7.41-7.33 (m, 1H), 2.55 (s, 3H),
2.33 (s, 3H), 2.17 (s, 3H), 2.06 (s, 3H).

10

<Example 46> Synthesis of N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula X-20)

The target compound was prepared according to the
15 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 11.33 (s, 1H), 10.17-9.79 (m,
1H), 8.55 (s, 1H), 8.04 (dd, J = 14.2, 7.7 Hz, 2H),
7.62-7.38 (m, 2H), 2.53 (s, 3H), 2.33 (s, 3H), 2.20
(s, 3H).

20

<Example 47> Synthesis of 3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula X-21)

The target compound was prepared according to the
25 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.26 (s, 1H), 8.67 (s, 1H), 8.13 (dd, J = 6.2, 3.0 Hz, 1H), 7.92 (dd, J = 6.3, 3.0 Hz, 1H), 7.61 (dd, J = 6.1, 3.2 Hz, 2H), 2.33 (s, 3H), 2.18 (s, 3H), 2.11 (s, 3H).

5

<Example 48> Synthesis of 3-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula X-22)

The target compound was prepared according to the
10 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.37 (s, 1H), 8.63 (s, 1H), 8.19-8.09 (m, 1H), 7.94-7.84 (m, 1H), 7.60 (dd, J = 6.1, 3.1 Hz, 2H), 2.33 (s, 3H), 2.18 (s, 3H), 2.12 (s, 3H).

15

<Example 49> Synthesis of 3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methylbenzo[b]thiophene-2-carboxamide (Formula X-23)

The target compound was prepared according to the
20 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.16 (s, 1H), 8.64 (s, 1H), 7.92 (s, 1H), 7.81 (d, J = 8.3 Hz, 1H), 7.44 (dd, J = 8.3, 0.9 Hz, 1H), 3.32 (s, 3H), 2.34 (s, 3H), 2.19 (s, 3H), 2.12 (s, 3H).

25

<Example 50> Synthesis of 3-chloro-6-fluoro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula X-24)

The target compound was prepared according to the
5 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.40 (s, 1H), 9.12 (s, 1H), 8.10 (dd, J = 9.1, 2.3 Hz, 1H), 7.96 (dd, J = 9.0, 5.1 Hz, 1H), 7.49 (td, J = 9.0, 2.4 Hz, 1H), 2.40 (s, 3H), 2.23 (s, 3H), 2.14 (s, 3H).

10

<Example 51> Synthesis of 3,6-dichloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula X-25)

The target compound was prepared according to the
15 method of general preparation procedure 2 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.27 (s, 1H), 8.65 (s, 1H), 8.34 (d, J = 1.6 Hz, 1H), 7.91 (d, J = 8.7 Hz, 1H), 7.63 (dd, J = 8.7, 1.9 Hz, 1H), 2.32 (s, 3H), 2.18 (s, 3H), 2.10 (s, 3H).

20

<Example 52> Synthesis of 3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methoxybenzo[b]thiophene-2-carboxamide (Formula X-26)

The target compound was prepared according to the
25 method of general preparation procedure 2 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.16 (s, 1H), 8.64 (s, 1H), 7.92 (s, 1H), 7.81 (d, J = 8.3 Hz, 1H), 7.44 (dd, J = 8.3, 0.9 Hz, 1H), 3.32 (s, 3H), 2.34 (s, 3H), 2.19 (s, 3H), 2.12 (s, 3H).

5

<Example 53> Synthesis of 3-chloro-6-fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula XI-01)

A 1:1 mixed solvent (2 mL) of THF and water was added to compound X-24 (20 mg), to which K₂CO₃ (76 mg) and CH₃I (34 μL) were sequentially added. The reaction mixture was stirred at room temperature for 24 hours and then concentrated under reduced pressure. The residue was diluted with CH₂Cl₂ and water, and the aqueous layer was extracted several times with CH₂Cl₂. The CH₂Cl₂ solution was dried over anhydrous MgSO₄, filtered, and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (CH₂Cl₂:MeOH=40:1) to give compound XI-01 (13 mg) as a white solid.

¹H-NMR ((CD₃)₂SO) δ 10.48 (s, 1H), 8.11 (dd, J = 9.1, 2.3 Hz, 1H), 8.00-7.92 (m, 1H), 7.50 (td, J = 9.0, 2.4 Hz, 1H), 3.69 (s, 3H), 2.37 (s, 3H), 2.23 (s, 3H), 2.12 (s, 3H).

25

<Example 54> Synthesis of 3-chloro-6-fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-yl)-N-methylbenzo[b]thiophene-2-carboxamide (Formula XI-02)

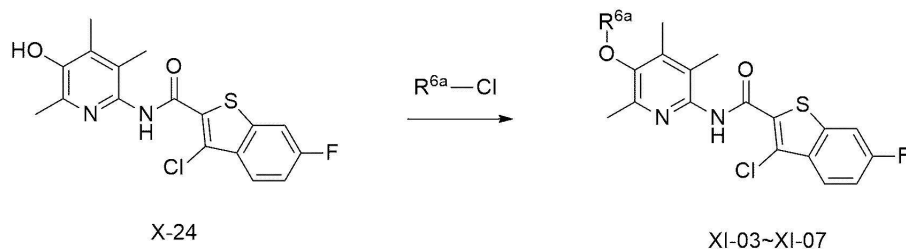
K₂CO₃ (17 mg) and CH₃I (13 µL) were sequentially
5 added to a DMF (1 mL) solution of compound X-24 (15 mg). The reaction mixture was stirred at room temperature for 24 hours. The reaction mixture was diluted with EtOAc and washed with water and saturated brine. The EtOAc solution was dried over anhydrous
10 MgSO₄, filtered, and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (EtOAc:Hexanes=3:7) to give compound XI-02 (10 mg) as a yellow solid.

¹H-NMR ((CD₃)₂SO) δ 7.90 (dd, *J* = 9.1, 2.3 Hz,
15 1H), 7.78 (dd, *J* = 8.9, 5.1 Hz, 1H), 7.36 (td, *J* = 9.0, 2.3 Hz, 1H), 3.59 (s, 3H), 3.25 (s, 3H), 2.24 (s, 4H), 2.13 (s, 3H), 2.10 (s, 3H).

<General preparation procedure 3 of examples>

20 According to the preparation method of reaction formula C below, the compounds of examples 55-59 (Compounds XI-03 ~ XI-07) were prepared.

[Reaction Formula C]



In reaction formula C above,

R^{6a} is $-(CH_2)_mC(=O)NH(CH_2)_nR^b$, and m , n and R^b are as defined in this specification.

5 NaH (0.3 mmol) and N-substituted-2-chloroacetamide (0.2 mmol) were sequentially added to a DMF (1 mL) solution of compound X-24 (0.1 mmol), followed by stirring at room temperature until the compound X-24 disappeared on TLC. The reaction mixture
10 was diluted with EtOAc and washed with water and saturated brine. The EtOAc solution was dried over anhydrous $MgSO_4$, filtered, and concentrated under reduced pressure. The obtained residue was purified by silica gel column chromatography to give compounds XI-
15 03 ~ XI-07.

<Example 55> Synthesis of 3-chloro-6-fluoro-N-(5-(2-(isopropylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
20 (Formula XI-03)

The target compound was prepared according to the method of general preparation procedure 3 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.49 (s, 1H), 8.11 (dd, *J* = 9.1, 2.3 Hz, 1H), 8.04 (d, *J* = 8.1 Hz, 1H), 7.96 (dd, *J* = 9.0, 5.1 Hz, 1H), 7.50 (td, *J* = 9.0, 2.4 Hz, 1H), 4.21 (s, 2H), 4.01 (tt, *J* = 13.2, 6.6 Hz, 1H), 2.38 (s, 3H), 2.25 (s, 3H), 2.12 (s, 3H), 1.14 (s, 3H), 1.13 (s, 3H).

10 <Example 56> Synthesis of 3-chloro-N-(5-(2-(cyclopropylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-6-fluorobenzo[b]thiophene-2-carboxamide (Formula XI-04)

15 The target compound was prepared according to the method of general preparation procedure 3 of examples.

¹H-NMR (CDCl₃) δ 9.19 (s, 1H), 7.89 (dd, *J* = 9.0, 4.9 Hz, 1H), 7.53 (dd, *J* = 8.3, 2.1 Hz, 1H), 7.33-7.22 (m, 1H), 6.86 (s, 1H), 4.25 (s, 2H), 2.90-2.82 (m, 1H), 2.48 (s, 3H), 2.28 (s, 3H), 2.22 (s, 3H), 0.92-20 0.84 (m, 2H), 0.68-0.61 (m, 2H).

 <Example 57> Synthesis of 3-chloro-N-(5-(2-(cyclohexylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-6-fluorobenzo[b]thiophene-2-carboxamide (Formula 25 XI-05)

The target compound was prepared according to the method of general preparation procedure 3 of examples.

¹H-NMR (CDCl₃) δ 9.25 (s, 1H), 7.90 (dd, *J* = 9.0, 4.9 Hz, 1H), 7.54 (dd, *J* = 8.3, 2.2 Hz, 1H), 7.32-7.23 (m, 1H), 6.67 (d, *J* = 8.3 Hz, 1H), 4.26 (s, 2H), 3.92 (dt, *J* = 10.5, 7.4 Hz, 1H), 2.51 (s, 3H), 2.30 (s, 3H), 2.23 (s, 3H), 2.04-1.97 (m, 2H), 1.81-1.72 (m, 2H), 1.66 (dd, *J* = 9.2, 3.8 Hz, 1H), 1.42 (ddd, *J* = 15.1, 9.0, 5.8 Hz, 2H), 1.34-1.26 (m, 2H), 1.21 (d, *J* = 3.6 Hz, 1H).

<Example 58> Synthesis of N-(5-(2-(benzylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-fluorobenzo[b]thiophene-2-carboxamide (Formula XI-06)

The target compound was prepared according to the method of general preparation procedure 3 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.50 (s, 1H), 8.83 (t, *J* = 6.2 Hz, 1H), 8.11 (dd, *J* = 9.1, 2.3 Hz, 1H), 7.96 (dd, *J* = 9.0, 5.1 Hz, 1H), 7.50 (td, *J* = 9.0, 2.4 Hz, 1H), 7.37-7.29 (m, 4H), 7.28-7.22 (m, 1H), 4.40 (d, *J* = 6.1 Hz, 2H), 4.33 (s, 2H), 2.39 (s, 3H), 2.26 (s, 3H), 2.12 (s, 3H).

<Example 59> Synthesis of 3-chloro-6-fluoro-N-(3,4,6-trimethyl-5-(2-oxo-2-(phenylamino)ethoxy)

pyridin-2-yl)benzo[b]thiophene-2-carboxamide (Formula XI-07)

The target compound was prepared according to the method of general preparation procedure 3 of examples.

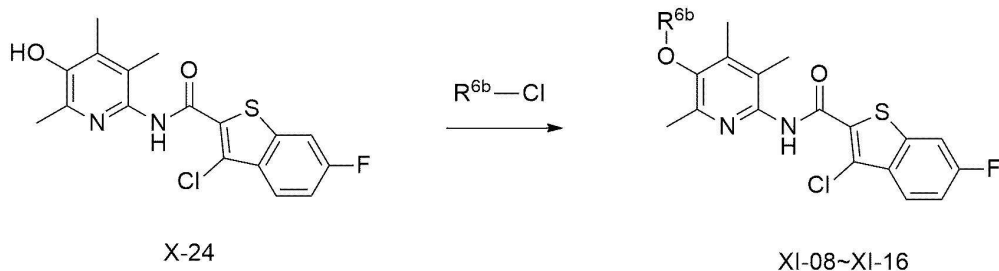
5 $^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.53 (s, 1H), 10.14 (s, 1H), 8.13 (dd, $J = 9.0, 2.3$ Hz, 1H), 7.98 (dd, $J = 8.9, 5.1$ Hz, 1H), 7.76-7.70 (m, 2H), 7.52 (td, $J = 9.0, 2.4$ Hz, 1H), 7.40-7.33 (m, 2H), 7.15-7.09 (m, 1H), 4.49 (s, 2H), 2.45 (s, 3H), 2.32 (s, 3H), 2.16 (s, 3H).

10

<General preparation procedure 4 of examples>

According to the preparation method of reaction formula D below, the compounds of examples 60-68 (Compounds XI-08 ~ XI-16) were prepared.

15 [Reaction Formula D]



In reaction formula D above,

R^{6b} is $-\text{C}(=\text{O})\text{R}^c$, and R^c is as defined in this specification.

20 Method (1): Et_3N (0.2 mmol) and acid chloride (0.1 mmol) were sequentially added to the CH_2Cl_2 (1 mL)

suspension of compound X-24 (0.1 mmol), followed by stirring at room temperature until the compound X-24 disappeared on TLC. The reaction mixture was diluted with CH₂Cl₂ and washed with water, saturated NaHCO₃ solution, water, and saturated brine in that order. The CH₂Cl₂ solution was dried over anhydrous MgSO₄, filtered, and concentrated under reduced pressure. The obtained residue was purified by silica gel column chromatography to give compounds XI-08 ~ XI-16.

Method (2): EDCI (0.15 mmol), HOBt (0.15 mmol) and Et₃N (0.25 mmol) were added to a DMF (1 mL) solution of compound X-24 (0.1 mmol). Carboxylic acid (0.2 mmol) was added thereto, and the reaction mixture was stirred at room temperature until the compound X-24 disappeared on TLC. The reaction mixture was diluted with CH₂Cl₂ and washed with water and saturated brine in that order. The CH₂Cl₂ solution was dried over anhydrous MgSO₄, filtered, and concentrated under reduced pressure. The obtained residue was purified by silica gel column chromatography to give compounds XI-08 ~ XI-16.

<Example 60> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl benzoate (Formula XI-08)

The target compound was prepared according to the method (1) of general preparation procedure 4 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.65 (s, 1H), 8.26-8.21 (m, 2H), 8.12 (dd, *J* = 9.1, 2.3 Hz, 1H), 7.98 (dd, *J* = 9.0, 5.1 Hz, 1H), 7.84-7.78 (m, 1H), 7.70-7.63 (m, 2H), 7.51 (td, *J* = 9.0, 2.4 Hz, 1H), 2.28 (s, 3H), 2.19 (s, 3H), 2.15 (s, 3H).

10 <Example 61> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 4-fluorobenzoate (Formula XI-09)

The target compound was prepared according to the method (1) of general preparation procedure 4 of
15 examples.

¹H-NMR (CDCl₃) δ 9.35 (s, 1H), 8.36-8.20 (m, 2H), 7.91 (dd, *J* = 9.0, 4.9 Hz, 1H), 7.54 (dd, *J* = 8.3, 2.1 Hz, 1H), 7.28 (dd, *J* = 8.9, 2.3 Hz, 1H), 7.26-7.20 (m, 2H), 2.44 (s, 3H), 2.28 (s, 3H), 2.23 (s, 3H).

20

 <Example 62> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 3-methoxybenzoate (Formula XI-10)

The target compound was prepared according to the method (1) of general preparation procedure 4 of examples.

¹H-NMR (CDCl₃) δ 9.21 (s, 1H), 7.89 (dd, *J* = 9.0, 5.0 Hz, 1H), 7.84 (d, *J* = 7.8 Hz, 1H), 7.71 (dd, *J* = 2.4, 1.5 Hz, 1H), 7.53 (dd, *J* = 8.3, 2.2 Hz, 1H), 7.45 (t, *J* = 8.0 Hz, 1H), 7.31-7.13 (m, 3H), 3.89 (s, 3H), 2.42 (s, 3H), 2.26 (s, 3H), 2.21 (s, 3H).

10 <Example 63> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 4-methoxybenzoate (Formula XI-11)

15 The target compound was prepared according to the method (1) of general preparation procedure 4 of examples.

¹H-NMR ((CD₃)₂SO) δ 10.63 (s, 1H), 8.21-8.15 (m, 2H), 8.12 (dd, *J* = 9.1, 2.4 Hz, 1H), 7.97 (dd, *J* = 8.9, 5.1 Hz, 1H), 7.51 (td, *J* = 9.0, 2.4 Hz, 1H), 20 7.21-7.14 (m, 2H), 3.90 (s, 3H), 2.26 (s, 3H), 2.18 (s, 3H), 2.13 (s, 3H).

 <Example 64> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-

trimethylpyridin-3-yl 5-fluoropicolinate (Formula XI-12)

The target compound was prepared according to the method (2) of general preparation procedure 4 of 5 examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.66 (s, 1H), 8.88 (d, J = 2.9 Hz, 1H), 8.45 (dd, J = 8.8, 4.5 Hz, 1H), 8.13 (dd, J = 9.1, 2.3 Hz, 1H), 8.05 (td, J = 8.6, 2.9 Hz, 1H), 7.98 (dd, J = 9.0, 5.1 Hz, 1H), 7.51 (td, J = 9.0, 2.4 10 Hz, 1H), 2.28 (s, 3H), 2.20 (s, 3H), 2.16 (s, 3H).

<Example 65> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 6-fluoronicotinate (Formula XI-15 13)

The target compound was prepared according to the method (2) of general preparation procedure 4 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.66 (s, 1H), 9.12 (d, J = 20 2.5 Hz, 1H), 8.79-8.73 (m, 1H), 8.13 (dd, J = 9.1, 2.3 Hz, 1H), 7.98 (dd, J = 9.0, 5.1 Hz, 1H), 7.55-7.47 (m, 2H), 2.29 (s, 3H), 2.20 (s, 3H), 2.17 (s, 3H).

<Example 66> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-25

trimethylpyridin-3-yl 5-chloropicolinate (Formula XI-14)

The target compound was prepared according to the method (2) of general preparation procedure 4 of 5 examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.66 (s, 1H), 8.93 (dd, J = 2.4, 0.6 Hz, 1H), 8.35 (dd, J = 8.4, 0.6 Hz, 1H), 8.27 (dd, J = 8.4, 2.4 Hz, 1H), 8.12 (dd, J = 9.1, 2.3 Hz, 1H), 7.98 (dd, J = 9.0, 5.1 Hz, 1H), 7.51 (td, J = 9.0, 2.4 Hz, 1H), 2.28 (s, 3H), 2.19 (s, 3H), 2.16 (s, 3H).

<Example 67> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 6-chloropicolinate (Formula XI-15)

The target compound was prepared according to the method (1) of general preparation procedure 4 of examples.

$^1\text{H-NMR}$ ($(\text{CD}_3)_2\text{SO}$) δ 10.66 (s, 1H), 9.22 (dd, J = 2.5, 0.6 Hz, 1H), 8.60 (dd, J = 8.4, 2.5 Hz, 1H), 8.12 (dd, J = 9.1, 2.3 Hz, 1H), 7.98 (dd, J = 9.0, 5.1 Hz, 1H), 7.83 (dd, J = 8.4, 0.6 Hz, 1H), 7.51 (td, J = 9.0, 2.4 Hz, 1H), 2.29 (s, 3H), 2.20 (s, 3H), 2.16 (s, 3H).

<Example 68> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl (3r,5r,7r)-adamantane-1-carboxylate (Formula XI-16)

The target compound was prepared according to the method (1) of general preparation procedure 4 of examples.

$^1\text{H-NMR}$ ((CD_3) $_2\text{SO}$) δ 10.58 (s, 1H), 8.12 (dd, J = 9.1, 2.3 Hz, 1H), 7.97 (dd, J = 9.0, 5.1 Hz, 1H), 7.51 (td, J = 9.0, 2.4 Hz, 1H), 2.20 (s, 3H), 2.15 (s, 3H), 2.07 (m, 12H), 1.76 (m, 6H).

<Example 69> Synthesis of 6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl morpholine-4-carboxylate (Formula XI-17)

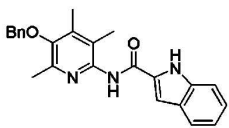
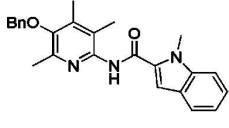
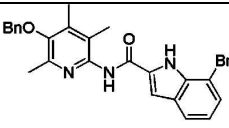
Compound X-24 (200 mg) and NaH (44 mg) were dissolved in DMF (1.8 mL), to which 1H-imidazol-1-yl-4-morpholinylmethanone (100 mg) was added, and the mixture was stirred at room temperature for 24 hours. The reaction solution was diluted with EtOAc and washed with water and saturated brine. The EtOAc solution was dried over anhydrous MgSO_4 , filtered, and concentrated under reduced pressure. The residue was

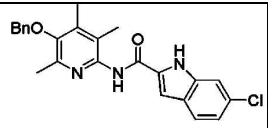
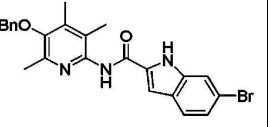
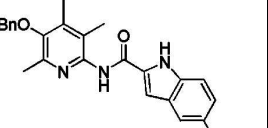
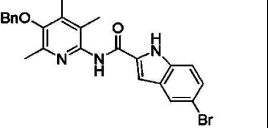
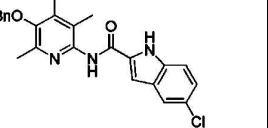
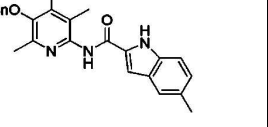
purified by column chromatography (CH₂Cl₂:MeOH=99:1) to give the target compound XI-17 (40 mg) as a yellow solid.

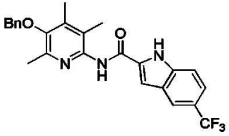
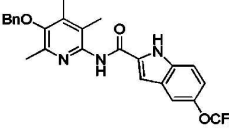
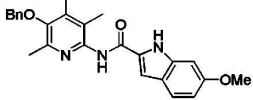
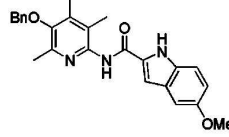
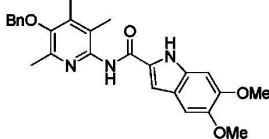
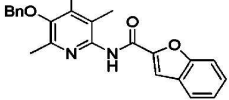
¹H-NMR ((CD₃)₂SO) δ 10.57 (s, 1H), 8.12 (dd, *J* = 9.1, 2.3 Hz, 1H), 7.97 (dd, *J* = 9.0, 5.1 Hz, 1H), 7.51 (td, *J* = 9.0, 2.4 Hz, 1H), 3.68 (s, 6H), 3.45 (d, *J* = 12.6 Hz, 2H), 2.26 (s, 3H), 2.15 (s, 3H), 2.12 (s, 3H).

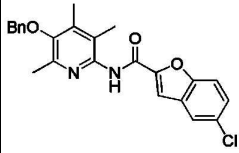
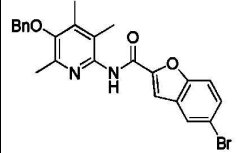
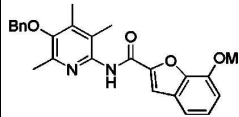
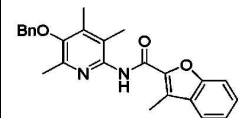
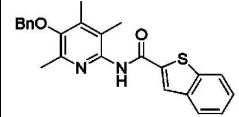
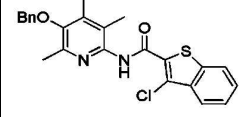
The numbers, chemical structures and names of the compounds of the present invention prepared above are summarized in Table 1 below.

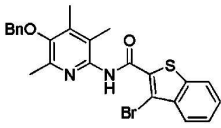
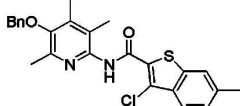
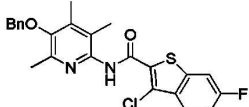
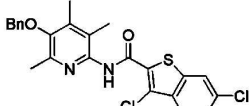
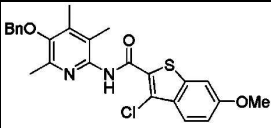
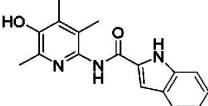
【Table 1】

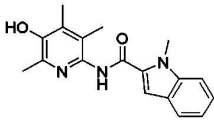
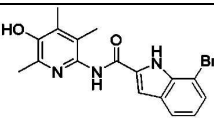
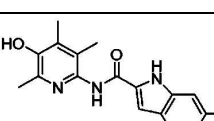
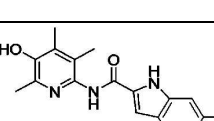
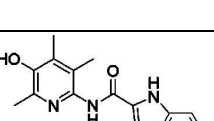
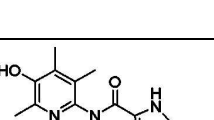
Number	Example	Structure	Name
IX-01	1		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide
IX-02	2		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-1-methyl-1H-indole-2-carboxamide
IX-03	3		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-7-bromo-1H-indole-2-carboxamide

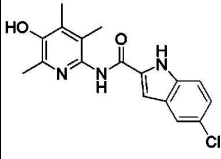
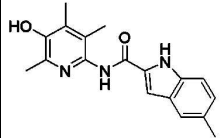
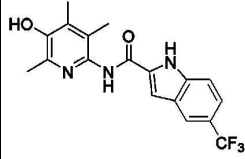
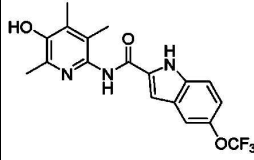
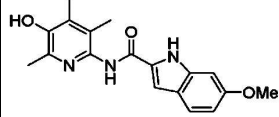
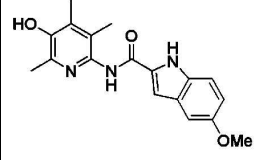
IX-04	4		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-chloro-1H-indole-2-carboxamide
IX-05	5		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-bromo-1H-indole-2-carboxamide
IX-06	6		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-fluoro-1H-indole-2-carboxamide
IX-07	7		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromo-1H-indole-2-carboxamide
IX-08	8		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chloro-1H-indole-2-carboxamide
IX-09	9		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methyl-1H-indole-2-carboxamide

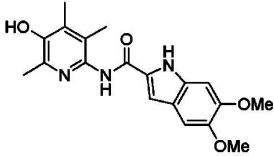
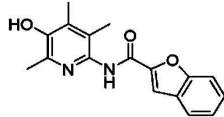
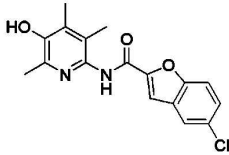
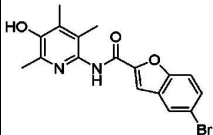
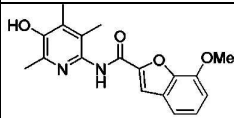
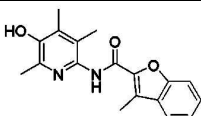
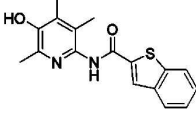
IX-10	10		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethyl)-1H-indole-2-carboxamide
IX-11	11		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethoxy)-1H-indole-2-carboxamide
IX-12	12		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-indole-2-carboxamide
IX-13	13		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-carboxamide
IX-14	14		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide
IX-15	15		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide

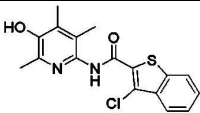
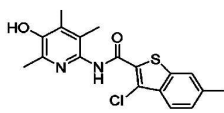
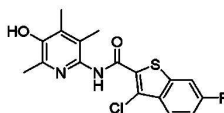
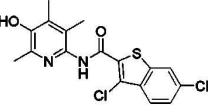
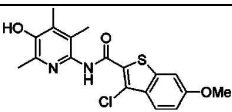
IX-16	16		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chlorobenzofuran-2-carboxamide
IX-17	17		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromobenzofuran-2-carboxamide
IX-18	18		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-7-methoxybenzofuran-2-carboxamide
IX-19	19		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-methylbenzofuran-2-carboxamide
IX-20	20		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
IX-21	21		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chlorobenzo[b]thiophene-2-carboxamide

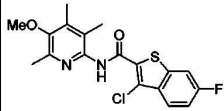
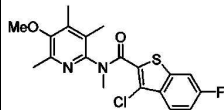
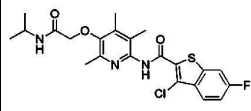
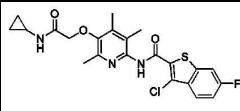
IX-22	22		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-bromobenzo[b]thiophene-2-carboxamide
IX-23	23		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-methylbenzo[b]thiophene-2-carboxamide
IX-24	24		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-fluorobenzo[b]thiophene-2-carboxamide
IX-25	25		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3,6-dichlorobenzo[b]thiophene-2-carboxamide
IX-26	26		N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-methoxybenzo[b]thiophene-2-carboxamide
X-01	27		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-3-carboxamide

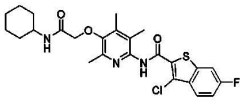
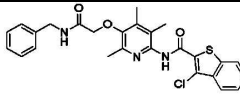
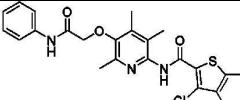
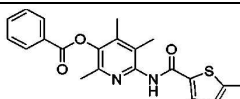
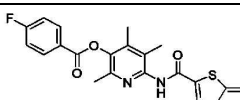
			indole-2-carboxamide
X-02	28		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1-methyl-1H-indole-2-carboxamide
X-03	29		7-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide
X-04	30		6-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide
X-05	31		6-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide
X-06	32		5-fluoro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide
X-07	33		5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide

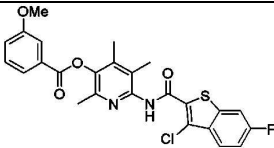
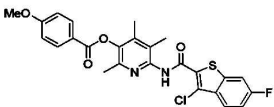
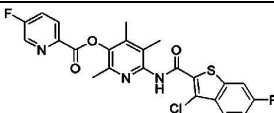
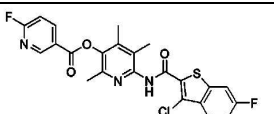
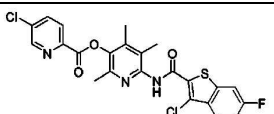
X-08	34		5-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide
X-09	35		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-methyl-1H-indole-2-carboxamide
X-10	36		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethyl)-1H-indole-2-carboxamide
X-11	37		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethoxy)-1H-indole-2-carboxamide
X-12	38		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-indole-2-carboxamide
X-13	39		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-carboxamide

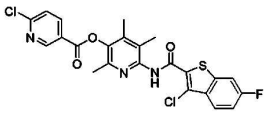
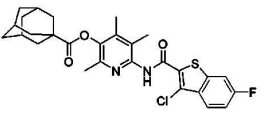
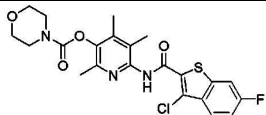
X-14	40		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide
X-15	41		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide
X-16	42		5-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide
X-17	43		5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide
X-18	44		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-7-methoxybenzofuran-2-carboxamide
X-19	45		N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-3-methylbenzofuran-2-carboxamide
X-20	46		N-(5-hydroxy-3,4,6-trimethylpyridin-2-

			yl)benzo[b]thiophene-2-carboxamide
X-21	47		3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
X-22	48		3-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
X-23	49		3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methylbenzo[b]thiophene-2-carboxamide
X-24	50		3-chloro-6-fluoro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
X-25	51		3,6-dichloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
X-26	52		3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-

			yl)-6-methoxybenzo[b]thiophene-2-carboxamide
XI-01	53		3-chloro-6-fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
XI-02	54		3-chloro-6-fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-yl)-N-methylbenzo[b]thiophene-2-carboxamide
XI-03	55		3-chloro-6-fluoro-N-(5-(2-(isopropylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide
XI-04	56		3-chloro-N-(5-(2-(cyclopropylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-6-fluorobenzo[b]thiophene-2-carboxamide

XI-05	57		3-chloro-N-(5-(2-(cyclohexylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-6-fluorobenzo[b]thiophene-2-carboxamide
XI-06	58		N-(5-(2-(benzylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-fluorobenzo[b]thiophene-2-carboxamide
XI-07	59		3-chloro-6-fluoro-N-(3,4,6-trimethyl-5-(2-oxo-2-(phenylamino)ethoxy)pyridin-2-yl)benzo[b]thiophene-2-carboxamide
XI-08	60		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl benzoate
XI-09	61		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 4-fluorobenzoate

			fluorobenzoate
XI-10	62		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 3-methoxybenzoate
XI-11	63		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 4-methoxybenzoate
XI-12	64		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 5-fluoropicolinate
XI-13	65		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 6-fluoronicotinate
XI-14	66		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 5-chloropicolinate

XI-15	67		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl 6-chloropicolinate
XI-16	68		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl (3r,5r,7r)-adamantane-1-carboxylate
XI-17	69		6-(3-chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-trimethylpyridin-3-yl morpholine-4-carboxylate

<Experimental Example 1> Activity test for inhibiting adhesion of monocytes and intestinal epithelial cells induced by TNF- α

5 <Test method>

HT-29 human colon cancer-derived epithelial cells and U937 human-derived monocytes were cultured in RPMI 1640 medium containing 10% FBS and 1% penicillin/streptomycin (PS) in a 37°C, 5% CO₂ incubator. When the cells grew more than 80% of the

10

bottom area of the culture flask, they were passaged at a ratio of 1:3 and used in this experiment. HT-29 cells were cultured in a 24-well plate at the density of 2×10^5 cells/cm², and the test drug was pretreated
5 in a medium containing 1% FBS and 1% PS for 1 hour. Thereafter, 10 µg/mL of BCECF-AM was treated thereto and reacted at 37°C for 30 minutes. U937 cells loaded with BCECF and TNF-α (10 ng/mL) were reacted with HT-29 cells previously treated with the test drug at 37°C
10 for 3 hours. Upon completion of the reaction, the medium was removed, and the culture flask was washed twice with PBS to remove non-adherent U937 cells. In the next step, the cells were lysed by treating with 0.1% Triton X-100 (0.1 M Tris) and reacted at room
15 temperature for 30 minutes. Then, fluorescence was measured and quantified using a fluostar optima microplate reader (BMG Labtechnologies, Germany) (Carvalho et al., 1996; Thapa et al., 2008).

Carvalho, D., Savage, C.O., Black, C.M. and
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【Table 2】

Compound	Inhibitory activity (%)	Compound	Inhibitory activity (%)	Compound	Inhibitory activity (%)
5-ASA	3.8	X-14	36.9	XI-03	60.6
		X-15	4.8	XI-04	13.9
X-01	43.2	X-16	25.1	XI-05	25.5
X-02	29.1	X-17	8.5	XI-06	62.1
X-03	14.5	X-18	55.1	XI-07	84.1
X-04	30.3	X-19	25.1	XI-08	7.7
X-05	7.5	X-20	16.5	XI-09	3.4
X-06	49.9	X-21	13.4	XI-10	46.5
X-07	88.9	X-22	26.8	XI-11	77.2
X-08	31.0	X-23	9.1	XI-12	31.9
X-09	82.8	X-24	90.3	XI-13	20.7
X-10	57.2	X-25	19.5	XI-14	38.1
X-11	32.8	X-26	45.1	XI-15	20.3

X-12	50.9	XI-01	9.3	XI-16	29.2
X-13	36.7	XI-02	18.5	XI-17	65.7

As shown in table 2 illustrating the results of investigating the inhibitory activity of the test drug (1 μ M) on the adhesion of intestinal epithelial cells (HT-29) and monocytic cells (U937) induced by TNF- α , the inhibitory rate of 5-ASA (positive control), an active metabolite of sulfasalazine which is a drug currently used in clinical trials for the treatment of inflammatory bowel disease, was 3.8%, showing little effect, whereas compound X-24 of the present invention exhibited the inhibitory rate of 90.3%, showing very excellent activity.

In addition, compound X-07 showed the inhibitory rate of 88.9%, compound XI-07 showed the inhibitory rate of 84.1%, compound X-09 showed the inhibitory rate of 82.8%, and compound XI-11 showed the inhibitory rate of 77.2%.

The compounds showing the inhibitory rate of 50% or more are listed in the order of excellent inhibitory activity as follows: compound XI-17 > compound XI-06 > compound XI-03 > compound X-10 > compound X-18 > compound X-12. Except for compound XI-

09, all other compounds were confirmed to have better inhibitory activity than that of 5-ASA.

From the above results, it was confirmed that the compound represented by formula 1 of the present invention can be effectively used for the treatment of inflammatory bowel disease, and it can be seen that the compound of the present invention can be used as a substitute for existing drugs.

10 **<Experimental Example 2> Activity test for inhibiting adhesion of monocytes and intestinal epithelial cells induced by IL-6**

 <Test method>

 The inhibitory activity test for intestinal epithelial cell-monocyte adhesion by IL-6 was performed using the same method as in the case of TNF- α . HT-29 cells were cultured in a 24-well plate at the density of 2×10^5 cells/cm², and the test drug was pretreated in a medium containing 1% FBS and 1% PS for 1 hour. Thereafter, 10 μ g/mL of BCECF-AM was treated thereto and reacted at 37°C for 30 minutes. U937 cells loaded with BCECF and IL-6 (10 ng/mL) were reacted with HT-29 cells previously treated with the test drug at 37°C for 3 hours. Upon completion of the reaction, the medium was removed, and the culture flask was

washed twice with PBS to remove non-adherent U937 cells. In the next step, the cells were lysed by treating with 0.1% Triton X-100 (0.1 M Tris) and reacted at room temperature for 30 minutes. Then, 5 fluorescence was measured and quantified using a fluostar optima microplate reader (BMG Labtechnologies, Germany).

【Table 3】

Compound	inhibitory activity (%)	Compound	inhibitory activity (%)	Compound	inhibitory activity (%)
5-ASA	< 1.7	X-14	29.5	XI-04	6.5
Tofacitinib	49.1	X-15	42.4	XI-05	14.5
		X-16	15.1	XI-06	54.1
X-01	34.0	X-17	3.6	XI-07	72.8
X-02	21.1	X-18	48.8	XI-08	6.8
X-03	5.0	X-19	18.7	XI-09	21.2
X-04	25.1	X-20	27.0	XI-10	13.1
X-05	3.4	X-21	11.4	XI-11	67.0
X-06	42.9	X-22	19.7	XI-12	18.0
X-07	80.3	X-23	8.7	XI-13	15.2
X-08	21.3	X-24	79.2	XI-14	26.8
X-09	71.7	X-25	9.0	XI-15	13.6
X-10	47.9	X-26	38.4	XI-16	20.3

X-11	24.2	XI-01	4.7	XI-17	59.6
X-12	46.0	XI-02	10.9		
X-13	23.4	XI-03	49.9		

As shown in table 3 illustrating the results of investigating the inhibitory activity of the test drug (1 μ M) on the adhesion of intestinal epithelial cells (HT-29) and monocytic cells (U937) induced by IL-6, the inhibitory rate of the existing drug 5-ASA was less than 1.7% at the concentration of 1 μ M, showing little effect, whereas tofacitinib showed the inhibitory rate of 49.1%.

The inhibitory rate of compound X-07 of the present invention was 80.3%, showing very good activity. In addition, compound X-24 showed the inhibitory rate of 79.2%, compound XI-07 showed the inhibitory rate of 72.8%, compound X-09 showed the inhibitory rate of 71.7%, compound XI-11 showed the inhibitory rate of 67%, compound XI-17 showed the inhibitory rate of 59.6%, and compound XI-06 showed the inhibitory rate of 54.1%. All other compounds were confirmed to have better inhibitory activity than that of 5-ASA.

The results (IC_{50}) of investigating the inhibitory activity of the two compounds having excellent activity on the adhesion of intestinal epithelial cells and monocytic cells induced by $TNF-\alpha$ and IL-6 are shown in table 4 below.

【Table 4】

Compound	$TNF-\alpha$ (IC_{50})	IL-6 (IC_{50})
5-ASA	18.1 mM	25.1 mM
Tofacitinib	0.70 μ M	0.44 μ M
X-09	0.30 μ M	0.34 μ M
X-24	0.23 μ M	0.35 μ M

As shown in table 4, in the case of 5-ASA used as a control drug, the IC_{50} for inhibition of adhesion by $TNF-\alpha$ was 18.1 mM, and the IC_{50} for inhibition of adhesion by IL-6 was 25.1 mM. On the other hand, in the case of compound X-09 of the present invention, the IC_{50} for inhibition of adhesion by $TNF-\alpha$ and IL-6 were 0.30 μ M and 0.34 μ M, respectively. In the case of compound X-24, the IC_{50} for inhibition of adhesion by $TNF-\alpha$ and IL-6 were 0.23 μ M and 0.35 μ M, respectively. Compounds X-09 and X-24 respectively showed excellent activity that was tens of thousands of times greater

than that of 5-ASA, and also showed superior activity compared to that of tofacitinib.

From the above results, it was confirmed that the compound represented by formula 1 of the present invention can be effectively used for the treatment of inflammatory bowel disease, and it can be seen that the compound of the present invention can be used as a substitute for existing drugs.

10 **<Experimental Example 3> In vivo efficacy test according to oral administration of compounds in TNBS-induced inflammatory bowel disease rat model**

 <Test method>

 Sprague Dawley rats aged 7-8 weeks were purchased from OrientBio (Korea), stabilized with general solid feed for 3 days, and then used in this experiment. Feed and water were freely supplied during the experiment period, and the temperature of the breeding room was maintained at 25±1°C and the relative humidity at 50±10%. Lighting management was controlled in a 12-hour light-dark cycle by an automatic lighting controller. Experimental groups were divided into 5 groups (control group, TNBS alone treated group, TNBS+sulfasalazine (300 mg/kg) treated group, TNBS+tofacitinib (30 mg/kg) treated group, TNBS+test

drug (1 mg/kg) treated group) in which 6 animals in each group and the average body weight were 180 ± 10 g according to a randomized block design.

5 (1) Inducing enteritis by rectal administration of TNBS

After anesthetizing rats that had been fasted for 24 hours with diethyl ether, 0.8 mL of 5% TNBS diluted with 50v/v% ethanol was slowly injected into the lumen
10 of the colon using a 1 mL syringe connected to a polyethylene catheter, and then, the rats were left standing for 60 seconds in an inverted position in order to prevent 5% TNBS from leaking into the anus. For the control group, only vehicle [50v/v% ethanol]
15 was injected in the same manner as in the other groups (Thapa et al., 2008).

(2) Drug administration

In order to investigate the effect of the drug,
20 the drug was administered at a constant time every day for 5 days from the day after the TNBS treatment.

(3) Weight observation

Changes in body weight of each rat were observed
25 from the fasting stage to the TNBS administration and

drug administration process using a digital mass meter.

(4) Measurement of colon weight

5 The colon of the rat was extracted, and the tissue 5-6 cm away from the anus was cut into a length of 1 cm, and the weight of the tissue was measured.

(5) Staining of colon tissue and measurement of
10 mucosal damage

 The weighed rat tissues were fixed with 4% paraformaldehyde solution, and then transferred to 30% sucrose solution. When the tissues subside, they were taken out and cut into 25 μm thick using a
15 cryomicrotome (Microm HM 450, Thermo Fisher Scientific, Germany) and stored in a cryopreservation solution. After washing the tissue section with KPBS, the tissue section was attached to a slide glass, dried, and then stained with hematoxylin & Eosin and
20 observed under a microscope. The degree of mucosal damage and recovery was scored as shown in table 5 below, and a total score of 6 points per rat was confirmed.

25 **【Table 5】**

Colon mucosal damage	Score
1) Inflammatory cell infiltration	
Occasional inflammatory cells in the lamina propria	0
Increased numbers of inflammatory cells in the lamina propria	1
Confluence of inflammatory cells, extending into the submucosa	2
Transmural extension of the infiltrate	3
2) Tissue damage	
No mucosal damage	0
Discrete lymphoepithelial lesions	1
Surface mucosal erosion or focal ulceration	2
Extensive mucosal damage and extension into deeper structures of the bowel wall	3

<Analysis of effect of oral administration of compounds on TNBS-induced enteritis>

The *in vivo* enteritis inhibitory activity at a fixed dose (1 mg/kg) of the compounds showing excellent activity in the *in vitro* adhesion inhibition test was measured as the intestinal weight recovery rate and body weight recovery rate, and the results are shown in table 6. In addition, the dose-dependent activity of compound X-09 is shown in table 7.

【Table 6】

Compound	Dose	Intestinal weight recovery rate	Body weight recovery rate (%)
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		(%)	
Sulfasalazine	300 mg/kg	69.6	86.6
X-24	1 mg/kg	97.4	86.6
X-07	1 mg/kg	94.9	72.9
X-09	1 mg/kg	94.0	72.7
XI-07	1 mg/kg	91.0	82.9
XI-17	1 mg/kg	79.8	60.2

【Table 7】

Compound	Dose	Intestinal weight recovery rate (%)	Body weight recovery rate (%)
Sulfasalazine	300 mg/kg	69.6	86.6
Triamcinolone	10 mg/kg	84.5	70.0
X-09	0.3 mg/kg	47.0	17.2
X-09	1 mg/kg	85.2	69.3
X-09	3 mg/kg	91.7	74.6
X-09	10 mg/kg	98.9	80.8

1. Weight change

5 In a colitis model in which intestinal inflammation was induced by treatment with 5% TNBS in rats weighing 180-190 g, the change in body weight was

observed at a certain time every day for 5 days based on the body weight before TNBS treatment. As a result, the body weight of the vehicle-treated control group rats continued to increase, and the weight of the TNBS-treated group rats continued to decrease, and the body weight recovered slightly from the 5th day, but the body weight was significantly reduced compared to the normal group rats. The body weight of the rats treated with 300 mg/kg of sulfasalazine, a positive control group, was gradually recovered, and although the body weight was decreased compared to that of the vehicle-treated control group rats, it was significantly increased compared to the body weight of the rats treated with TNBS alone, resulting in a weight recovery rate of 50.5%. The pyridinol compounds showed a recovery rate of 60.2% ~ 86.6% when 1 mg/kg was administered. The compounds are listed in the order of excellent weight recovery rate as follows: compounds X-24, XI-07, X-07, X-09, and XI-17. For compound X-09, the dose-dependent activity was measured by adding 10 mg/kg of triamcinolone in addition to 300 mg/kg of sulfasalazine, a positive control. As a result, it was confirmed that the compound X-09 exhibited a dose-dependent body weight

recovery activity and was more effective than triamcinolone at the same concentration.

2. Morphological observation

5 After 5 days of drug administration, the colon was extracted and visually inspected. As a result, the colon of the rats treated with TNBS showed edema and hyperemia compared to the control group rats, and edema and congestion of the appendix and adhesions of
10 the intestinal tissues were observed. In the group treated with 300 mg/kg of sulfasalazine, a positive control group, the symptoms observed with the naked eye and adhesions between other organs and colonic congestion were also significantly suppressed. In the
15 group treated with the pyridinol compound, the symptoms improved more than the group treated with 300 mg/kg of sulfasalazine. It was also confirmed that the compound X-09 exhibited a dose-dependent therapeutic activity for enteritis and was more effective than
20 triamcinolone at the same concentration.

3. Measurement of colon weight

The degree of inflammation of the rat colon is a key scale (important index) of IBD progression that is
25 more important than body weight change. The colon was

extracted and the weight of the tissue 5-6 cm away from the anus was measured. As a result, the weight of the colon with edema was significantly increased in the rats of the group treated with TNBS alone, 5 compared to the vehicle-treated control group rats. In the rats of the group treated with 300 mg/kg of sulfasalazine, a positive control, the weight recovery rate of the colon tissue was 69.6%. The pyridinol compounds showed a recovery rate of 79.8% ~ 97.4% when 10 1 mg/kg was administered. The compounds are listed in the order of excellent weight recovery rate as follows: compounds X-24, XI-07, X-07, X-09, and XI-17. It was also confirmed that the compound X-09 exhibited a dose-dependent body weight recovery activity and was 15 more effective than triamcinolone at the same concentration.

4. Measurement of mucosal damage recovery of rat colon

20 After observing the morphology of the colon in the dose-dependent activity measurement experiment, hematoxylin-eosin staining of the colon tissue was performed to score and compare the degree of colon mucosal damage. As a result, it was confirmed that the 25 compound X-09 exhibited a dose-dependent mucosal

damage recovery activity and was more effective than triamcinolone at the same concentration (Figure 1).

From the results of Experimental Example 3, it was confirmed that the compound represented by formula 1 of the present invention can be effectively used for the treatment of inflammatory bowel disease, and it can be seen that the compound of the present invention can be used as a substitute for existing drugs.

10 **<Experimental Example 4> In vivo efficacy test according to oral administration of compounds in dextran sulfate sodium (DSS)-induced inflammatory bowel disease mouse model**

 <Test method>

15 C57BL/6 mice aged 7-8 weeks were purchased from OrientBio (Korea), stabilized with general solid feed for 7 days, and then used in this experiment. Feed and water were freely supplied during the experiment period, and the temperature of the breeding room was maintained at 25±1°C and the relative humidity at 50±10%. Lighting management was controlled in a 12-hour light-dark cycle by an automatic lighting controller.

(1) Inducing acute·chronic enteritis by DSS and measuring preventive and therapeutic effects of drugs

Enteritis was induced in mice by allowing them to freely ingest drinking water containing 2% DSS salt (M.W. 36,000~50,000, MP Biomedicals, LLC, OH, USA). For the chronic enteritis model, DSS was administered using a schedule of DSS administration for the first 7 days, administration of normal drinking water for 14 days, repeated administration of DSS for 7 days from the 21st day, and administration of normal drinking water for 7 days. The drug was administered once a day, 6 days a week from the first day of DSS treatment (Figure 2A). Experimental groups were divided into 6 groups (control group, DSS alone treated group, DSS+sulfasalazine (300 mg/kg) treated group, DSS+tofacitinib (30 mg/kg) treated group, DSS+test drug (1 mg/kg) treated group, and DSS+test drug (3 mg/kg) treated group) in which 6 animals in each group and the average body weight were 20±1 g according to a randomized block design. In order to measure the dose-dependent therapeutic effect of the drug in the acute enteritis model, DSS was administered for 5 days to induce enteritis, and then the drug was administered for 14 days to measure the degree of recovery and treatment of enteritis (Figure 3A). The drug was

administered orally once daily for 10 days at a fixed time.

(2) Weight observation

5 Changes in body weight of each mouse were observed during the DSS and drug administration using a digital mass meter.

(3) Measurement of colon length and weight

10 The colon of the mouse was extracted, and the length and weight from the anus to the cecum were measured.

(4) Measurement of MPO

15 The degree of neutrophil infiltration in the tissue was measured by the amount of MPO, a neutrophil marker enzyme. The colon tissue with a size of 1 cm was washed with cold PBS and weighed, to which a lysis buffer (pH7.4, 200 mM NaCl, 5 mM EDTA, 10 mM tris, 10%
20 glycerin, 1 mM PMSF, 1 µg/mL leupeptin and 28 µg/mL aprotinin) was added (500 µL of per 10 mg of tissue weight), and then homogenized using Bead Blaster® D2400 homogenizer (Benchmark Scientific, NJ, USA). The homogenized sample was centrifuged twice at 1500 × g
25 for 5 minutes to obtain a supernatant, and then 100 µL

of this supernatant was measured using a kit. The homogenized sample was centrifuged twice at 1500×g for 5 minutes to obtain a supernatant, and then 100 µL of this supernatant was measured using MPO ELISA kit
5 (HK210, Hycult Biotechnology, Netherlands). The supernatant was added to a 96 well plate (100 µL/well) coated with an anti-mouse MPO antibody, and incubated for 1 hour at room temperature, followed by washing 3 times with a washing buffer. A reconstituted tracer
10 was added to the plate (100 µL/well), which was reacted at room temperature for 1 hour, washed 3 times, and then 100 µL of streptavidin-peroxidase conjugate was added to each well of the plate. The plate was reacted at room temperature for 1 hour,
15 washed, and 100 µl of TMB substrate solution was added to each well of the plate, followed by reaction for 30 minutes. The reaction was terminated by adding 100 µL of a stop solution to each well of the plate, and absorbance was measured at 450 nm. MPO activity means
20 the amount of 1 µM hydrogen peroxide reduced from water at 25°C for 1 minute. This was calculated as the amount of MPO contained in 1 mL of the colon tissue homogenate.

25 (5) Tissue staining

Tissue staining was performed in the same manner as in the case of hematoxylin/eosin staining of the rat colon tissue, and scoring indexes of mucosal damage and recovery were applied in the same way.

5

<Analysis of effect of oral administration of compounds on DSS-induced acute and chronic mouse enteritis>

The inhibitory activity of compound X-24 against DSS-induced chronic mouse enteritis was measured, and the results are shown in table 8. The dose-dependent therapeutic efficacy of compound X-09 on DSS-induced acute mouse enteritis was measured, and the results are shown in table 9.

15

【Table 8】

Compound	Dose	Chronic enteritis (DSS-water-DSS administration/total 35 days)	
		Intestinal weight recovery rate (%)	Body weight recovery rate (%)
Sulfasalazine	300 mg/kg	66.9	22.8
Tofacitinib	30 mg/kg	68.2	29.5
X-24	1 mg/kg	58.1	22.8
X-24	3 mg/kg	98.2	73.3

【Table 9】

Compound	Dose	Acute enteritis	
		Intestinal weight recovery rate (%)	Body weight recovery rate (%)
Sulfasalazine	300 mg/kg	66.2	65.9
Tofacitinib	30 mg/kg	80.9	80.8
X-09	0.3 mg/kg	48.4	56.5
X-09	1 mg/kg	76.7	72.0
X-09	3 mg/kg	89.0	80.7
X-09	10 mg/kg	96.4	88.1

1. Weight change

In a chronic enteritis model in which chronic inflammation was induced by supplying water containing 2% DSS for 7 days, water for 14 days, and then water containing 2% DSS for 7 days in mice weighing 19-21 g, the efficacy of the pyridinol compound was measured. The changes in body weight were observed in the chronic enteritis model. As a result, the weight of the vehicle-treated control group mouse continued to increase, and the weight of the DSS-treated group mouse was decreased due to the DSS treatment and began to recover the weight while drinking water, but the weight significantly decreased again due to the second DSS administration. The weight recovery rate of the mouse of the group treated with 300 mg/kg of

sulfasalazine or 30 mg/kg of tofacitinib, a positive control group, after 35 days was 22.8% and 29.4%, respectively, compared to the vehicle-treated control group mouse. On the other hand, the mouse of the group
5 treated with the pyridinol compound X-24 showed a dose-dependent body weight recovery rate (22.8%, 73.3%) (Figure 2B).

In an acute enteritis model in which intestinal inflammation was induced by supplying water containing
10 2% DSS for 7 days in mice weighing 19-21 g, the change in body weight was observed at a certain time every day based on the body weight before DSS treatment. As a result, the body weight of the vehicle-treated control group mice continued to increase, and the
15 weight of the DSS-treated group mice continued to decrease, and thus the body weight was significantly reduced compared to the normal group mice. The body weight of the mice treated with 300 mg/kg of sulfasalazine or 30 mg/kg of tofacitinib, a positive
20 control group, was gradually recovered, and although the body weight was decreased compared to that of the vehicle-treated control group rats, it was significantly increased compared to the body weight of the mice treated with DSS alone, resulting in a weight
25 recovery rate of 65.9% and 80.9%, respectively. The

dose-dependent efficacy of the compound X-09 on DSS-induced acute intestinal inflammation according to the oral administration was measured. As a result, the mice of the group treated with the pyridinol compound X-09 showed weight recovery rates of 56.5, 72.0, 80.7, and 88.1% at the compound concentrations of 0.3, 1, 3, and 10 mg/kg, respectively (Figure 3B).

2. Morphological observation

After 7 days of drug administration, the colon was extracted and visually inspected. As a result, the colon of the mice treated with DSS was significantly shorter compared to the control group, and edema and hyperemia were observed. In addition, edema and congestion of the appendix and adhesions of intestinal tissues were observed. In the group treated with 300 mg/kg of sulfasalazine or 30 mg/kg of tofacitinib, a positive control group, the recovery of intestinal length was observed, and the macroscopic symptoms and adhesions between other organs and colonic congestion were also significantly suppressed. In the group treated with the pyridinol compound, it was observed that the symptoms were more ameliorated than the group treated with 30 mg/kg of tofacitinib as well as the group treated with 300 mg/kg of sulfasalazine (Figure

2C). The compound X-09 showed a dose-dependent therapeutic efficacy, and the therapeutic effect in the group treated with 10 mg/kg of the compound X-09 was significantly superior to that of the control
5 group treated with 30 mg/kg of tofacitinib (Figure 3C).

3. Measurement of colon weight

The colon of the mouse was extracted and the
10 tissue weight between the anus and the cecum was measured. As a result, the weight of the colon with edema was significantly increased in the mice of the group treated with DSS alone, compared to the vehicle-treated control group mice. In the case of the chronic
15 enteritis model, the recovery rate of intestinal tissue weight of the mice treated with 300 mg/kg of sulfasalazine or 30 mg/kg of tofacitinib, a positive control, was 67.3% and 68.8%, respectively. Compound X-24 showed dose-dependent recovery rates (58.1% and
20 98.2%) at 1 mg/kg and 3 mg/kg (Figure 2D).

The therapeutic efficacy of the compounds was measured in the acute enteritis model. As a result, the intestinal tissue weight recovery was observed in the group treated with 300 mg/kg of sulfasalazine or
25 30 mg/kg of tofacitinib, a positive control. Compound

X-09 showed a dose-dependent effect, and exhibited a superior effect than the positive control group at 3 mg/kg and 10 mg/kg (Figure 3D). In addition, the level of MPO, a biochemical index of tissue inflammation, was measured. As a result, the level of MPO significantly increased by DSS was decreased by compound X-09 dose-dependently, and the groups treated with the compound X-09 at the concentrations of 3 mg/kg and 10 mg/kg showed a superior effect than the positive control group (Figure 3E).

4. Measurement of mucosal damage recovery of mouse colon

After observing the morphology of the colon in the dose-dependent activity measurement experiment, hematoxylin-eosin staining of the colon tissue was performed to score and compare the degree of colon mucosal damage. As a result, the compound X-09 showed a dose-dependent mucosal damage recovery effect, and it was confirmed that the effect was superior to that of the control group, tofacitinib (Figure 4).

From the results of Experimental Example 4, it was confirmed that the compound represented by formula 1 of the present invention can be effectively used for the treatment of inflammatory bowel disease, and it

can be seen that the compound of the present invention
can be used as a substitute for existing drugs.

<Experimental Example 5> In vivo efficacy test
5 **according to oral administration of compounds in**
collagen-induced rheumatoid arthritis animal model

<Test method>

12-week-old normal male mice and arthritis-
induced DBA/1J mice were purchased from Central Lab.
10 Animal Inc [To induce arthritis, DBA/1J mice were
sensitized by injecting a mixed solution of Complete
Freund's Adjuvant (CFA; DIFCO, Detroit, MI) and Bovine
Type II collagen (1:1, v/v) intradermally at the pinna
base at 8 weeks of age, and then, secondary
15 sensitization was performed by intradermal injection
at the tail head at 11 weeks of age]. The purchased
arthritis mice were acclimatized to the laboratory
environment for a week, and then oral administration
of the drug was started.

20

(1) Visual observation and measurement of
arthritis

Visual observation of arthritic lesions was
performed using the following scores based on a
25 reference (Barnett et al., 1998).

0: No edema or swelling,
1: Mild swelling and redness localized to the
foot or ankle joint,
2: Mild swelling and redness from the ankle joint
5 to the tarsal bone,
3: Moderate swelling and redness from the ankle
joint to the tarsal bone,
4: Swelling, redness and joint stiffness from the
ankle to the entire leg.

10 Therefore, the highest score for arthritic
lesions was 16 per mouse. Observations were performed
twice a week for 5 weeks from the day of drug
administration, and the evaluation data were prepared
by two people who did not know the experimental group
15 and the control group.

In addition, photographs were taken to visually
identify the degree of arthritis.

(2) Measurement of hind paw thickness

20 The hind paw thickness, which is one of the
pathological indices of rheumatoid arthritis, was
measured using a caliper.

(3) Articular tissue staining

The right hind leg of each mouse was extracted, and all skin and muscles were removed, leaving only the bones and joints. The hind leg was fixed in 4% paraformaldehyde solution for 2 days, then immersed in 10% formic acid for 5 days to decalcify, and then immersed in 30% sucrose solution. When the tissue subsided, the articular tissue was cut into 30 μ m thick using a cryomicrotome (Microm HM 450, Thermo Fisher Scientific, Germany) and stored in a cryopreservation solution. Staining was performed using the stored tissue sections. After attaching the tissue sections to the slide glass, they were hydrated with 100%, 95%, 70%, and 50% ethanol solutions, and some were stained with safranin and others were stained with hematoxylin/eosin. For safranin staining, the tissue sections were first stained with 0.1% fast green solution, washed with 1% acetic acid solution, and then stained with 1% safranin solution. Thereafter, the tissue sections were dehydrated by immersing in ethanol solutions in the reverse order of hydration, and then preserved in xylene solution and mounting solution, and photographed under a microscope. Hematoxylin/eosin staining was performed in the same manner as in the colon tissue staining. The tissue sections were dehydrated, preserved in

xylene solution and mounting solution, and observed under a microscope.

The degree of microscopic tissue damage of the stained articular tissue was measured using the following scores.

- Grade 1: No damage on articular surface,
- Grade 2: Discontinuous articular surface,
- Grade 3: Vertical cracks in joint,
- Grade 4: Corrosion in joint,
- Grade 5: Exposure of joint erosion,
- Grade 6: Joint deformity.

(4) Lymphocyte isolation and stimulation

After the spleen and draining lymph nodes of the mice were extracted, the number of immune cells was counted. To confirm the distribution of Th1 and Th17 cells, the immune cells obtained from each organ were stimulated using PMA/Ionomycin and Golgi stop.

After staining using an anti-IFN- γ antibody that can identify Th1 cells, an anti-IL-17 antibody that can identify Th17 cells, and an anti-CD8 antibody that can identify cytotoxic T cells, the proportion of inflammatory cells among the total immune cells was confirmed using flow cytometry.

Barnett ML, Kremer JM, St Clair EW, Clegg DO, Furst D, Weisman M, et al. Treatment of rheumatoid arthritis with oral type II collagen. Results of a multicenter, double-blind, placebo-controlled trial.
5 Arthritis Rheum 1998; 41:290-7.

<Analysis of effect of oral administration of compound X-09 in collagen-induced rheumatoid arthritis (CIA) animal model>

10 The visual observation scores and weight changes for the degree of arthritis are shown in Figure 5. Arthritis-induced mice exhibited an average arthritis score of 12.8 at a nearly similar level until the 4th day of drug administration. The mice in the vehicle-
15 administered group maintained the degree of arthritis without improvement, and exhibited an arthritis index of 13.8 points on the 35th day. However, when tofacitinib or Compound X-09 was administered, the degree of arthritis was significantly improved dose
20 dependently. On the 35th day of drug administration, the group treated with 50 mg/kg of compound X-09 showed the best efficacy with an arthritis score of 7.2, followed by the group treated with 50 mg/kg of tofacitinib, the group treated with 10 mg/kg of
25 compound X-09, and the group treated with 1 mg/kg of

compound X-09 (Figure 5A). The hind paw thickness of arthritic mice was 2.58 to 2.61 mm on the fourth day of drug administration, which was significantly increased compared to the average hind paw thickness of normal mice, 1.64 mm. On day 35th day of drug administration, the hind paw thickness increased by inflammatory edema was maintained at 2.65 mm, and was significantly reduced to 1.70 mm in the group treated with 50 mg/kg of compound X-09, and the hind paw thickness was reduced in the order of the group treated with 50 mg/kg of tofacitinib, the group treated with 10 mg/kg of compound X-09, and the group treated with 1 mg/kg of compound X-09 (Figure 5B). The body weight of the arthritis mice was significantly reduced compared to that of the normal mice of the same age, and the body weight was gradually recovered in proportion to the degree of arthritis improvement (Figure 5C).

The weekly changes in the degree of arthritis of the hind paws were shown as photographic images (Figure 6). The articular tissue was stained with hematoxylin & eosin and safranin O, and the degree of recovery of the articular tissue was converted into a score (Figure 7).

After 35 days of drug administration, immune cells were isolated from the spleen and draining lymph nodes and analyzed. As a result, it was confirmed that the total number of immune cells in the spleen was not significantly different from that of the normal group (Figure 8A), but the number of inflammatory cells Th1 and Th17 and the number of activated CD8 cells were significantly reduced. From the above results, it was confirmed that the dose-dependent decrease by the compound X-09 (Figure 8B). The number of inflammatory cells Th1 and Th17 and the number of activated CD8 cells secreting interferon gamma were also significantly reduced in the draining lymph node (Figure 8C), and the compound X-09 showed a dose-dependent effect.

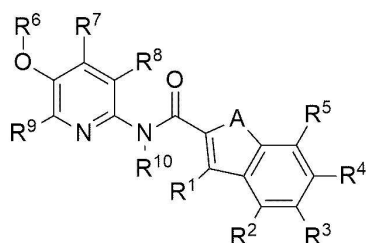
From the above results, it was confirmed that the compound represented by formula 1 of the present invention can be effectively used for the treatment of rheumatoid arthritis.

Therefore, the compounds according to the present invention can be effectively used as a pharmaceutical composition for the prevention and treatment of autoimmune diseases, in particular, inflammatory bowel disease or rheumatoid arthritis, as confirmed in the above experiments.

WHAT IS CLAIMED IS:

1. A compound represented by formula 1, an isomer thereof, a solvate thereof, a hydrate thereof or a
5 pharmaceutically acceptable salt thereof:

[Formula 1]



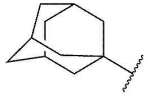
(In formula 1,

A is NR^a, O or S, wherein, the R^a is hydrogen, or
10 straight chained or branched C₁₋₅ alkyl;

R¹, R², R³, R⁴, and R⁵ are independently hydrogen, halogen, straight chained or branched C₁₋₅ alkyl, or straight chained or branched C₁₋₅ alkoxy, wherein the alkyl and alkoxy may be independently substituted with
15 one or more halogens;

R⁶ is hydrogen, straight chained or branched C₁₋₅ alkyl, -(CH₂)_mC(=O)NH(CH₂)_nR^b or -C(=O)R^c, wherein the alkyl may be substituted with one or more halogens, and m and n are independently integers of 0 to 5,

20 R^b is hydrogen, straight chained or branched C₁₋₁₀ alkyl, C₃₋₁₀ cycloalkyl or C₆₋₁₀ aryl,

R^c is adamantanyl (, 3 - 10 membered heterocycloalkyl containing one or more hetero atoms selected from the group consisting of N, O and S, C₆₋₁₀ aryl, or 5 - 10 membered heteroaryl containing one or
5 more hetero atoms selected from the group consisting of N, O and S, wherein the aryl and heteroaryl may be independently substituted with at least one selected from the group consisting of halogen, straight chained or branched C₁₋₅ alkyl and straight chained or branched
10 C₁₋₅ alkoxy;

R⁷, R⁸, and R⁹ are independently straight chained or branched C₁₋₅ alkyl; and

R¹⁰ is hydrogen, or straight chained or branched C₁₋₅ alkyl).

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2. The compound, the isomer thereof, the solvate thereof, the hydrate thereof or the pharmaceutically acceptable salt thereof according to claim 1, wherein:

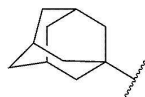
A is NR^a, O or S, wherein the R^a is hydrogen, or
20 straight chained or branched C₁₋₃ alkyl;

R¹, R², R³, R⁴, and R⁵ are independently hydrogen, halogen, straight chained or branched C₁₋₃ alkyl, or straight chained or branched C₁₋₃ alkoxy, wherein the

alkyl and alkoxy may be independently substituted with one or more halogens;

R^6 is hydrogen, straight chained or branched C_{1-3} alkyl, $-(CH_2)_mC(=O)NH(CH_2)_nR^b$, or $-C(=O)R^c$, wherein the
5 alkyl may be substituted with one or more halogens, and m and n are independently integers of 0 to 3,

R^b is hydrogen, straight chained or branched C_{1-6} alkyl, C_{3-8} cycloalkyl or phenyl,



R^c is adamantanyl (), 3 - 8 membered
10 heterocycloalkyl containing one or more hetero atoms selected from the group consisting of N, O and S, phenyl, or 5 - 6 membered heteroaryl containing one or more hetero atoms selected from the group consisting of N, O and S, wherein the phenyl and heteroaryl may
15 be independently substituted with at least one selected from the group consisting of halogen, straight chained or branched C_{1-3} alkyl and straight chained or branched C_{1-3} alkoxy;

R^7 , R^8 , and R^9 are independently straight chained
20 or branched C_{1-3} alkyl; and

R^{10} is hydrogen, or straight chained or branched C_{1-3} alkyl.

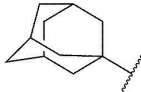
3. The compound, the isomer thereof, the solvate thereof, the hydrate thereof or the pharmaceutically acceptable salt thereof according to claim 1, wherein:

A is NR^a , O or S, wherein the R^a is hydrogen or
5 methyl;

R^1 , R^2 , R^3 , R^4 , and R^5 are independently hydrogen, -Cl, -Br, -F, methyl, methoxy, $-\text{CF}_3$ or $-\text{OCF}_3$;

R^6 is hydrogen, methyl, $-(\text{CH}_2)_m\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{R}^b$, or $-\text{C}(=\text{O})\text{R}^c$, wherein m is 1, and n is 0 or 1,

10 R^b is hydrogen, straight chained or branched C_{1-3} alkyl, C_{3-6} cycloalkyl or phenyl,

R^c is adamantanyl (, 6 membered heterocycloalkyl containing one or more hetero atoms selected from the group consisting of N, O and S,
15 phenyl, or 6 membered heteroaryl containing one or more hetero atoms selected from the group consisting of N, O and S, wherein the phenyl and heteroaryl may be independently substituted with at least one selected from the group consisting of halogen, and
20 straight chained or branched C_{1-3} alkoxy;

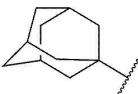
R^7 , R^8 , and R^9 are methyl; and

R^{10} is hydrogen or methyl.

4. The compound, the isomer thereof, the solvate thereof, the hydrate thereof or the pharmaceutically acceptable salt thereof according to claim 1, wherein:

R^6 is hydrogen, methyl, $-(CH_2)C(=O)NHR^b$, or $-C(=O)R^c$,

R^b is hydrogen, isopropyl, cyclopropyl, cyclohexyl, phenyl or benzyl,

R^c is adamantanyl () , morpholinyl, phenyl or pyridinyl, wherein the phenyl and pyridinyl may be independently substituted with at least one selected from the group consisting of F, Cl and methoxy.

5. The compound, the isomer thereof, the solvate thereof, the hydrate thereof or the pharmaceutically acceptable salt thereof according to claim 1, wherein the compound represented by formula 1 is selected from the group consisting of the following compounds:

<1> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <2> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-1-methyl-1H-indole-2-carboxamide; <3> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-7-bromo-1H-indole-2-carboxamide; <4> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-chloro-1H-indole-2-

carboxamide; <5> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-bromo-1H-indole-2-carboxamide;

carboxamide; <6> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-fluoro-1H-indole-2-carboxamide;

5 carboxamide; <7> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromo-1H-indole-2-carboxamide;

carboxamide; <8> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chloro-1H-indole-2-carboxamide;

carboxamide; <9> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methyl-1H-indole-2-carboxamide;

10 carboxamide; <10> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethyl)-1H-indole-2-carboxamide;

carboxamide; <11> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-(trifluoromethoxy)-1H-indole-2-carboxamide;

15 2-carboxamide; <12> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-indole-2-carboxamide;

carboxamide; <13> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-carboxamide;

carboxamide; <14> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide;

20 carboxamide; <15> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzofuran-2-carboxamide; <16> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-chlorobenzofuran-2-carboxamide; <17> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-5-bromobenzofuran-2-

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carboxamide; <18> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-7-methoxybenzofuran-2-carboxamide; <19> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-methylbenzofuran-2-carboxamide; <20> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide; <21> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chlorobenzo[b]thiophene-2-carboxamide; <22> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-bromobenzo[b]thiophene-2-carboxamide; <23> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-methylbenzo[b]thiophene-2-carboxamide; <24> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-fluorobenzo[b]thiophene-2-carboxamide; <25> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3,6-dichlorobenzo[b]thiophene-2-carboxamide; <26> N-(5-(benzyloxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-methoxybenzo[b]thiophene-2-carboxamide; <27> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <28> N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1-methyl-1H-indole-2-carboxamide; <29> 7-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <30> 6-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide; <31> 6-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-

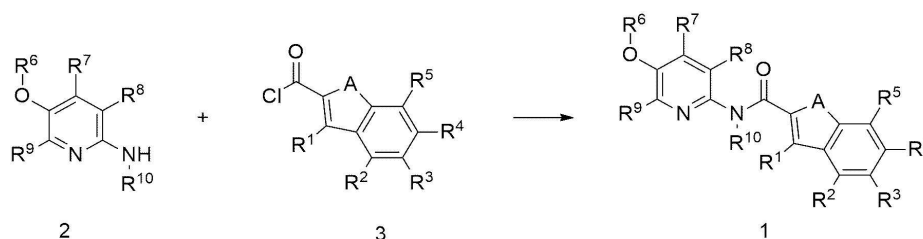
indole-2-carboxamide; <32> 5-fluoro-N-(5-hydroxy-
3,4,6-trimethylpyridin-2-yl)-1H-indole-2-carboxamide;
<33> 5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-
yl)-1H-indole-2-carboxamide; <34> 5-chloro-N-(5-
5 hydroxy-3,4,6-trimethylpyridin-2-yl)-1H-indole-2-
carboxamide; <35> N-(5-hydroxy-3,4,6-trimethylpyridin-
2-yl)-5-methyl-1H-indole-2-carboxamide; <36> N-(5-
hydroxy-3,4,6-trimethylpyridin-2-yl)-5-
(trifluoromethyl)-1H-indole-2-carboxamide; <37> N-(5-
10 hydroxy-3,4,6-trimethylpyridin-2-yl)-5-
(trifluoromethoxy)-1H-indole-2-carboxamide; <38> N-(5-
hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methoxy-1H-
indole-2-carboxamide; <39> N-(5-hydroxy-3,4,6-
trimethylpyridin-2-yl)-5-methoxy-1H-indole-2-
15 carboxamide; <40> N-(5-hydroxy-3,4,6-trimethylpyridin-
2-yl)-5,6-dimethoxy-1H-indole-2-carboxamide; <41> N-
(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzofuran-2-
carboxamide; <42> 5-chloro-N-(5-hydroxy-3,4,6-
trimethylpyridin-2-yl)benzofuran-2-carboxamide; <43>
20 5-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-
yl)benzofuran-2-carboxamide; <44> N-(5-hydroxy-3,4,6-
trimethylpyridin-2-yl)-7-methoxybenzofuran-2-
carboxamide; <45> N-(5-hydroxy-3,4,6-trimethylpyridin-
2-yl)-3-methylbenzofuran-2-carboxamide; <46> N-(5-
25 hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-

2-carboxamide; <47> 3-chloro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide;
 <48> 3-bromo-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide; <49> 3-chloro-N-
 5 (5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methylbenzo[b]thiophene-2-carboxamide; <50> 3-chloro-
 6-fluoro-N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide; <51> 3,6-dichloro-
 N-(5-hydroxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide; <52> 3-chloro-N-
 10 (5-hydroxy-3,4,6-trimethylpyridin-2-yl)-6-methoxybenzo[b]thiophene-2-carboxamide; <53> 3-chloro-
 6-fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide; <54> 3-chloro-6-
 15 fluoro-N-(5-methoxy-3,4,6-trimethylpyridin-2-yl)-N-methylbenzo[b]thiophene-2-carboxamide; <55> 3-chloro-
 6-fluoro-N-(5-(2-(isopropylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)benzo[b]thiophene-2-carboxamide;
 <56> 3-chloro-N-(5-(2-(cyclopropylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-6-
 20 fluorobenzo[b]thiophene-2-carboxamide; <57> 3-chloro-N-(5-(2-(cyclohexylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-6-fluorobenzo[b]thiophene-2-carboxamide; <58> N-(5-(2-(benzylamino)-2-oxoethoxy)-3,4,6-trimethylpyridin-2-yl)-3-chloro-6-
 25

fluorobenzo[b]thiophene-2-carboxamide; <59> 3-chloro-
 6-fluoro-N-(3,4,6-trimethyl-5-(2-oxo-2-
 (phenylamino)ethoxy)pyridin-2-yl)benzo[b]thiophene-2-
 carboxamide; <60> 6-(3-chloro-6-
 5 fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl benzoate; <61> 6-(3-chloro-6-
 fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 4-fluorobenzoate; <62> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 10 trimethylpyridin-3-yl 3-methoxybenzoate; <63> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 4-methoxybenzoate; <64> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 5-fluoropicolinate; <65> 6-(3-
 15 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 6-fluoronicotinate; <66> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl 5-chloropicolinate; <67> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 20 trimethylpyridin-3-yl 6-chloropicolinate; <68> 6-(3-
 chloro-6-fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 trimethylpyridin-3-yl (3r,5r,7r)-adamantane-1-
 carboxylate; <69> 6-(3-chloro-6-
 fluorobenzo[b]thiophene-2-carboxamido)-2,4,5-
 25 trimethylpyridin-3-yl morpholine-4-carboxylate.

6. A method for preparing a compound represented by formula 1 comprising a step of preparing a compound represented by formula 1 by reacting a compound represented by formula 2 with a compound represented by formula 3, as shown in reaction formula 1 below:

[Reaction Formula 1]



(In reaction formula 1,

10 A, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, and R¹⁰ are as defined in formula 1 of claim 1).

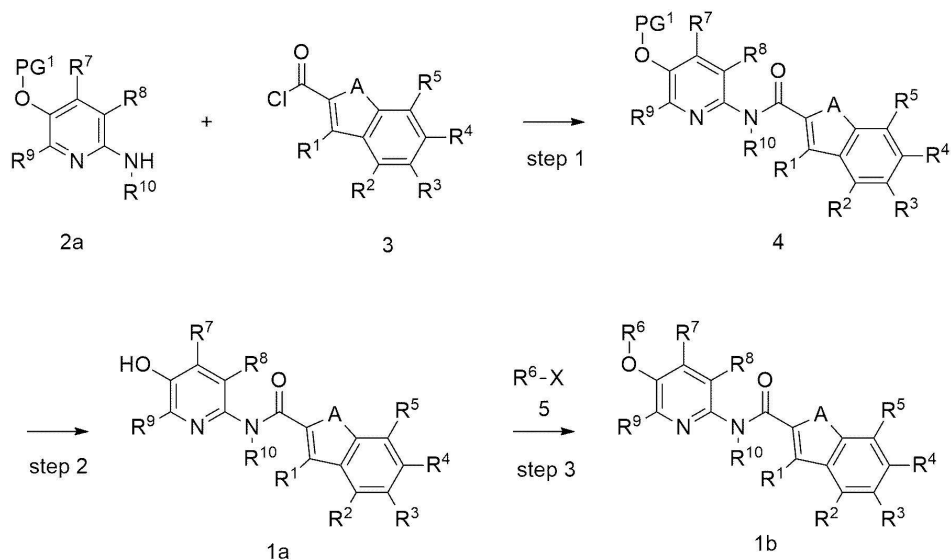
7. A method for preparing a compound represented by formula 1 comprising the following steps, as shown in reaction formula 2 below:

preparing a compound represented by formula 4 by reacting a compound represented by formula 2a with a compound represented by formula 3 (step 1);

preparing a compound represented by formula 1a by deprotecting the compound represented by formula 4 obtained in step 1 above (step 2); and

preparing a compound represented by formula 1b by reacting the compound represented by formula 1a obtained in step 2 above with a compound represented by formula 5 (step 3):

5 [Reaction Formula 2]



(In reaction formula 2,

A, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, and R¹⁰ are as defined in formula 1 of claim 1 except when R⁶ is
 10 hydrogen;

the compound represented by formula 1a is a derivative of formula 1 wherein R⁶ is hydrogen;

the compound represented by formula 1b is a derivative of formula 1 except when R⁶ is hydrogen;

15 PG¹ is an alcohol protecting group selected from the group consisting of acetyl (Ac), benzoyl (Bz),

benzyl (Bn), methylthiomethyl ether, MEM (β -methoxyethoxymethyl ether), DMT (dimethoxytrityl, [bis-(4-methoxyphenyl)phenylmethyl]), MOM (methoxymethyl ether), MMT (methoxytrityl [(4-methoxyphenyl)diphenylmethyl]), PMP (p-methoxybenzyl ether), Piv (pivaloyl), THP (tetrahydropyranyl), THF (tetrahydrofuran) and Trityl (triphenylmethyl, Tr); and

X is halogen).

10

8. A pharmaceutical composition comprising a compound represented by formula 1 of claim 1, an isomer thereof, a solvate thereof, a hydrate thereof or a pharmaceutically acceptable salt thereof as an active ingredient for the prevention or treatment of autoimmune disease.

9. The pharmaceutical composition according to claim 8, wherein the compound inhibits the adhesion of monocytes to intestinal epithelial cells by TNF- α or IL-6.

10. The pharmaceutical composition according to claim 8, wherein the autoimmune disease is at least one selected from the group consisting of inflammatory

bowel disease, asthma, type 1 diabetes, rheumatoid
arthritis, polymyalgia rheumatica, ankylosing
spondylitis, psoriatic arthritis, psoriasis, eczema,
sclerosis, vitiligo, multiple sclerosis, IL-17-induced
5 dementia, peripheral neuritis, uveitis,
polymyositis/dermatomyositis, autoimmune cytopenia,
autoimmune myocarditis, atopic dermatitis, primary
cirrhosis, dry eye syndrome, fibromyalgia,
Goodpasture's syndrome, autoimmune meningitis,
10 Sjogren's syndrome, systemic lupus erythematosus,
Addison's disease, alopecia areata, autoimmune
hepatitis, autoimmune mumps, dystrophic epidermolysis
bullosa, epididymitis, glomerulonephritis, Graves'
disease, celiac disease, Guillain-Barré syndrome,
15 Hashimoto's disease, hemolytic anemia, myasthenia
gravis, amyotrophic lateral sclerosis, pemphigus
vulgaris, rheumatic fever, sarcoidosis, skin
sclerosis, spondyloarthrosis, thyroiditis, vasculitis,
vitiligo, myxedema, pernicious anemia,
20 antiphospholipid syndrome, late and chronic rejection
of solid organ transplantation, and graft-versus-host
disease.

11. The pharmaceutical composition according to
25 claim 10, wherein the inflammatory bowel disease is at

least one selected from the group consisting of
enteritis, colitis, ulcerative enteritis, Crohn's
disease, Crohn's cytoma, irritable bowel syndrome,
hemorrhagic rectal ulcer, pouchitis, peptic ulcer,
5 intestinal Behcet's disease and gastritis.