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(54) Title: PIPERIDINE OR PIPERAZINE LINKED IMIDAZOLE AND TRIAZOLE DERIVATIVES AND METHODS OF USE THEREOF FOR IMPROVING THE PHARMACOKINETICS OF A DRUG

(57) Abstract: The piperidine or piperazine linked imidazole and triazole derivatives, compositions comprising said compounds, alone or in combination with other drugs, and methods of using the compounds for improving the pharmacokinetics of a drug are provided. The compounds of the invention are useful in human and veterinary medicine for inhibiting CYP3A4 and for improving the pharmacokinetics of a therapeutic compound that is metabolized by CYP3A4.



PIPERIDINE OR PIPERAZINE LINKED IMIDAZOLE AND TRIAZOLE
DERIVATIVES AND METHODS OF USE THEREOF FOR IMPROVING THE
PHARMACOKINETICS OF A DRUG

5 BACKGROUND OF THE INVENTION

The cytochrome P450 enzyme system (CYP450) is responsible for the biotransformation of drugs from active substances to inactive metabolites that can be excreted from the body. In addition, the metabolism of certain drugs by CYP450 can alter their PK profile and result in sub-therapeutic plasma levels of those drugs over time. In the area of anti-
10 viral therapy, this can lead to resistance of the virus to the drug.

The virus causing acquired immunodeficiency syndrome (AIDS) is known by various names, including human immunodeficiency virus (HIV), of which two distinct families have been identified – HIV-1 and HIV-2. Many inhibitors of HIV, including HIV protease inhibitors, HIV integrase inhibitors and non-nucleoside reverse transcriptase inhibitors are
15 metabolized by CYP450. This metabolic activity can lead to unfavorable pharmacokinetics, requiring administering more frequent and/or higher doses than are optimal.

Many drugs, including some HIV protease inhibitors, are now paired with other agents that improve exposure of the drug, with the drug-drug interaction being commonly referred to as "boosting." International Publication Nos. WO 2006/108879, WO 2007/034312
20 and WO 2008/010921; U.S. Patent Publication No. US 2009/0175820; and U.S. Patent No. 7,919,488 describe compounds useful as pharmacokinetic enhancers.

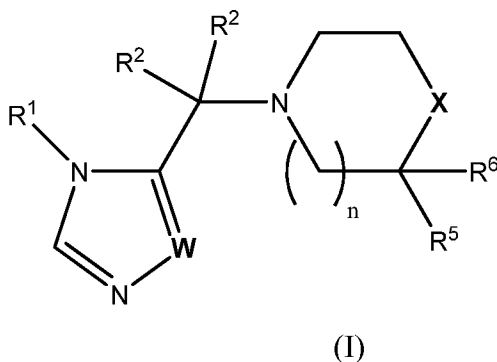
Ritonavir, a common boosting agent, is widely used with HIV agents and is an HIV protease inhibitor itself that exerts its boosting effect through inhibition of Cytochrome P450 3A4 (CYP3A4) and p-glycoprotein drug transporters. Ritonavir, however, is associated
25 with certain risks, including hepatotoxicity, hyperlipidemia and unfavorable gastrointestinal effects.

SUMMARY OF THE INVENTION

The present invention relates to piperidine or piperazine linked imidazole and triazole derivatives, compositions comprising said compounds, alone or in combination with
30 other drugs, and methods of using the compounds for improving the pharmacokinetics of a drug. The compounds of the invention are useful in human and veterinary medicine for inhibiting CYP3A4 and for improving the pharmacokinetics of a therapeutic compound that is metabolized by CYP3A4.

DETAILED DESCRIPTION OF THE INVENTION

The invention encompasses a genus of compounds having the formula (I):



or a pharmaceutically acceptable salt thereof,

wherein:

n is 0 or 1;

W is $-\text{N}=\text{}$ or $-\text{CH}=\text{}$;

X is $-\text{C}(\text{R}^3)(\text{R}^4)-$, $-\text{N}(\text{R}^3)-$ or $-\text{S}(\text{O})_2-$;

R^1 is selected from $-(\text{C}_1-\text{C}_6 \text{ alkylene})\text{-aryl}$, $-(\text{C}_1-\text{C}_6 \text{ alkylene})\text{-(5 or 6-membered heteroaryl)}$, $-(\text{C}_1-\text{C}_6 \text{ alkylene})\text{-O-aryl}$, $-(\text{C}_1-\text{C}_6 \text{ alkylene})\text{-O-(5 or 6-membered heteroaryl)}$ and $\text{C}_3\text{-C}_6 \text{ cycloalkyl}$, wherein any aryl, heteroaryl or $\text{C}_3\text{-C}_6 \text{ cycloalkyl}$ group can be optionally substituted with up to four R^9 groups, which can be the same or different, and wherein said $\text{C}_3\text{-C}_6 \text{ cycloalkyl}$ group can be fused to a benzene ring and said fused benzene ring can be optionally substituted with up to four R^9 groups, which can be the same or different;

each occurrence of R^2 is independently selected from H, $\text{C}_1\text{-C}_6 \text{ alkyl}$, $-\text{OH}$, $-\text{O-(C}_1\text{-C}_6 \text{ alkyl)}$ and $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-O-(C}_1\text{-C}_6 \text{ alkyl)}$; or the two R^2 groups can be joined together with the atom to which they are attached to form a $\text{C}_3\text{-C}_6 \text{ cycloalkyl}$ ring;

R^3 and R^4 are independently selected from H, halo, $-\text{OH}$, $-\text{CN}$, Y, $-\text{O-Y}$, $-\text{C(O)-Y}$, $-\text{C(O)-O-Y}$, $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-Y}$, $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-C(O)-Y}$, $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-C(O)-O-Y}$ and $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-O-Y}$, wherein each Y is independently selected from:

- (1) $\text{C}_1\text{-C}_6 \text{ alkyl}$,
- (2) $\text{C}_1\text{-C}_6 \text{ haloalkyl}$,
- (3) $\text{C}_1\text{-C}_6 \text{ hydroxyalkyl}$,
- (4) $\text{C}_3\text{-C}_6 \text{ cyclohaloalkyl}$,
- (5) $\text{C}_3\text{-C}_6 \text{ cycloalkyl}$,

(6) phenyl, wherein said phenyl group can be optionally substituted with up to four R^7 groups,

(7) 5 or 6-membered heteroaryl, wherein said 5 or 6-membered heteroaryl group can be optionally substituted with up to four R^7 groups, and

(8) 5 or 6-membered monocyclic heterocycloalkyl or 9 or 10-membered bicyclic heterocycloalkyl, wherein said 5 or 6-membered monocyclic heterocycloalkyl group can optionally form a spirocycle with a C_3 - C_6 cycloalkyl group or another 5 or 6-membered monocyclic heterocycloalkyl group, and wherein said 5 or 6-membered monocyclic heterocycloalkyl group and said 9 or 10-membered bicyclic heterocycloalkyl group can be optionally substituted on one or more ring carbon atoms with up to four R^7 groups, which can be the same or different, and wherein a ring carbon atom of a 5 or 6-membered monocyclic heterocycloalkyl group may be functionalized as a carbonyl group;

or R^3 and R^4 together with the carbon atom to which they are attached are joined together to form a 5 or 6-membered monocyclic heterocycloalkyl group, wherein said heterocycloalkyl group can be optionally substituted on one or more ring carbon atoms with up to four R^7 groups, which can be the same or different, and wherein a ring carbon atom of a 5 or 6-membered monocyclic heterocycloalkyl group may be functionalized as a carbonyl group;

R^5 is selected from H, C_1 - C_6 alkyl, phenyl, $-C(O)N(R^8)_2$ and $-C(O)-Z$, wherein Z is selected from piperidinyl, piperazinyl and morpholinyl and wherein said Z is optionally substituted with 1 to 3 halo groups, and phenyl is optionally substituted with $-N(R^8)_2$,

R^6 is H or may be joined together with R^5 to form carbonyl,

each occurrence of R^7 and each occurrence of R^9 are independently selected from C_1 - C_6 alkyl, phenyl, benzyl, 5 or 6-membered heteroaryl, $-CH_2$ -(5 or 6-membered heteroaryl), 5 or 6-membered heterocycloalkyl, $-CH_2$ -(5 or 6-membered heterocycloalkyl), C_1 - C_6 hydroxyalkyl,

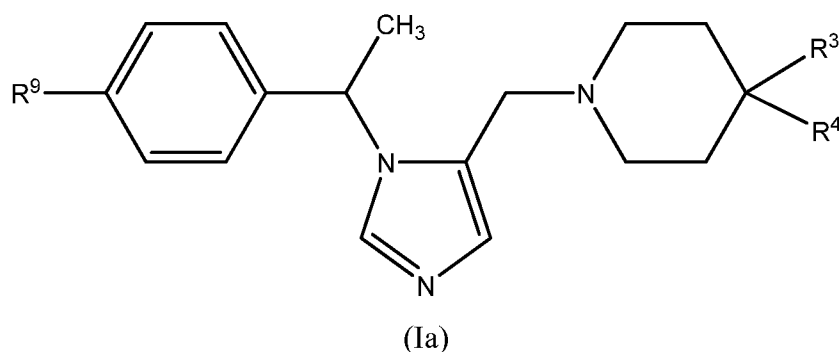
C_1 - C_6 haloalkyl, halo, $-CN$, $-N(R^8)_2$, $-(C_1-C_6 \text{ alkylene})-N(R^8)_2$, $-OR^8$, $-C(O)OR^8$, $-SR^8$, $-S(O)_2R^8$, $-C(O)N(R^8)_2$, $-(C_1-C_6 \text{ alkylene})-C(O)OR^8$, $-(C_1-C_6 \text{ alkylene})-SR^8$, $-(C_1-C_6 \text{ alkylene})-S(O)_2R^8$ and $-(C_1-C_6 \text{ alkylene})-C(O)N(R^8)_2$, wherein said phenyl, 5 or 6-membered heteroaryl and 5 or 6-membered heterocycloalkyl groups can be optionally substituted with one

to three groups selected from C₁-C₆ alkyl, halo, C₁-C₆ hydroxyalkyl, C₁-C₆ haloalkyl, halo, -CN, -N(R⁸)₂ and

-OR⁸; and

each occurrence of R⁸ is independently H, C₁-C₆ alkyl or benzyl optionally substituted with one or two methoxy groups ("Embodiment E1").

In another embodiment (Embodiment E2"), the invention encompasses compounds having the formula (Ia):



or a pharmaceutically acceptable salt thereof, wherein R³, R⁴ and R⁹ are defined as in Embodiment E1.

In another embodiment (Embodiment E3"), the invention encompasses compounds of formula (Ia), or a pharmaceutically acceptable salt thereof, wherein R⁹ is -F or -CN, and R³ and R⁴ are defined as in Embodiment E1.

In another embodiment (Embodiment E4"), the invention encompasses compounds of formula (Ia), or a pharmaceutically acceptable salt thereof, wherein

R³ is selected from (1) C₁-C₆ alkyl, (2) C₃-C₆ cycloalkyl, (3) phenyl, wherein said phenyl group can be optionally substituted with up to four halo groups, (4) 5 or 6-membered heteroaryl, wherein said 5 or 6-membered heteroaryl group can be optionally substituted with methyl, and (5) 5 or 6-membered monocyclic heterocycloalkyl; and

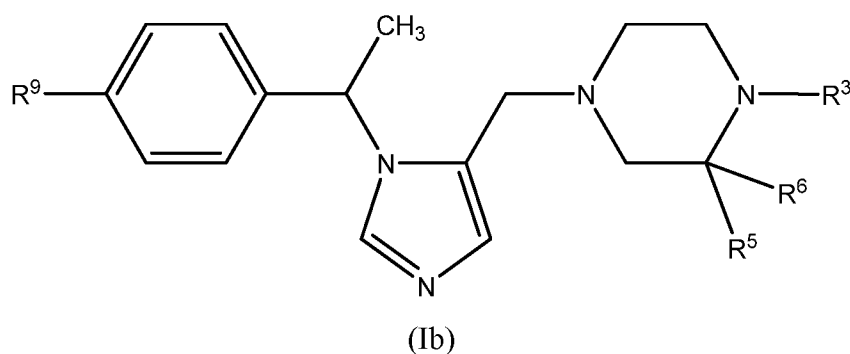
R⁴ is selected from -CN or -CH₃, and R⁹ is defined as in Embodiment E1 or Embodiment E2.

In another embodiment (Embodiment E5"), the invention encompasses compounds of formula (Ia), or a pharmaceutically acceptable salt thereof, wherein

R^3 is selected from benzo[d]oxazol-2-yl and benzo[d]thiazol-2-yl, said benzo[d]oxazol-2-yl and benzo[d]thiazol-2-yl groups each optionally substituted with 1 to 3 groups independently selected from: halo, $-CH_3$ and $-OCH_3$; and

R^4 is H, and R^9 is defined as in Embodiment E1 or Embodiment E2.

In another embodiment (Embodiment E6''), the invention encompasses compounds having the formula (Ib):



or a pharmaceutically acceptable salt thereof, R^3 , R^5 , R^6 and R^9 are defined as in Embodiment E1.

In another embodiment (Embodiment E7''), the invention encompasses compounds of formula (Ib), or a pharmaceutically acceptable salt thereof, wherein R^9 is $-F$ or $-CN$, and R^3 , R^5 and R^6 is defined as in Embodiment E1.

In another embodiment (Embodiment E8''), the invention encompasses compounds of formula (Ib), or a pharmaceutically acceptable salt thereof, wherein R^3 is thiazolyl substituted with $-(C_1-C_6 \text{ alkylene})-S(O)_2R^8$, R^5 is H and R^6 is H, and R^9 is defined as in Embodiment E1 or Embodiment E7.

In another embodiment (Embodiment E9''), the invention encompasses compounds of formula (Ib), or a pharmaceutically acceptable salt thereof, wherein R^3 is phenyl, R^5 is $-C(O)-Z$, wherein Z is selected from piperidinyl, piperazinyl and morpholinyl and wherein said Z is optionally substituted with 1 to 3 halo groups, and R^6 is H, and R^9 is defined as in Embodiment E1 or Embodiment E7.

In another embodiment (Embodiment E10''), the invention encompasses compounds of formula (Ib), or a pharmaceutically acceptable salt thereof, wherein R^3 is $-C(O)-Y$, Y is selected from (1) C_1-C_6 alkyl, (2) 1-methylcyclopropyl, (3) cyclobutyl optionally substituted with one or two halo groups, (4) phenyl, (5) pyridinyl, and (6) tetrahydro-2H-pyran-4-yl, R^5 is

selected from H, C₁-C₄ alkyl and phenyl, and R⁶ is H, and R⁹ is defined as in Embodiment E1 or Embodiment E7.

In another embodiment (Embodiment E11”), the invention encompasses compounds of formula (Ib), or a pharmaceutically acceptable salt thereof, wherein

5 R³ is -CH₂-Y,

Y is selected from phenyl, imidazo[1,2-a]pyridinyl, oxadiazolyl and thiazolyl, wherein said Y is optionally substituted with a group selected from: (1) phenyl wherein said phenyl is optionally substituted with one or two methoxy groups, (2) -N(R⁸)₂, (3) morpholinyl, (4) piperazinyl wherein said piperazinyl is optionally substituted with a methyl group, and (5)
10 triazolylmethyl; and

R⁵ and R⁶ are joined together to form carbonyl, and R⁹ is defined as in Embodiment E1 or Embodiment E7.

In another embodiment (Embodiment E12”), the invention encompasses compounds of formula (Ib), or a pharmaceutically acceptable salt thereof, wherein

15 R³ is selected from C₁-C₆ hydroxyalkyl, -(C₁-C₆ alkylene)-C(O)-Y, -(C₁-C₆ alkylene)-C(O)-O-Y and -(C₁-C₆ alkylene)-O-Y, where Y is C₁-C₆ alkyl;

and

R⁵ is H and R⁶ is H, and R⁹ is defined as in Embodiment E1 or Embodiment E7.

Another embodiment of the invention encompasses a Compound of Formula (I),
20 or a pharmaceutically acceptable salt thereof, wherein W is -C(H)-, X is -C(R³)(R⁴)- or -N(R³)-, n is 1, R¹ is -(C₁-C₄ alkylene)-phenyl wherein said phenyl portion is substituted at the 4-position with -F or -CN, both R² groups are H, and all other variable are defined as in Embodiment E1.

In another embodiment, the Compounds of Formula (I) are in substantially purified form.

25 Other embodiments of the present invention include the following:

(a) A pharmaceutical composition comprising an effective amount of a Compound of Formula (I) or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

(b) The pharmaceutical composition of (a), further comprising one or more
30 therapeutic compounds that are metabolized by CYP3A, preferably CYP3A4.

(c) The pharmaceutical composition of (b), wherein the therapeutic compound is an anti-HIV drug, preferably the anti-HIV drug(s) are selected from the group consisting of HIV protease inhibitors, HIV integrase inhibitors nucleoside reverse transcriptase inhibitors and non-nucleoside reverse-transcriptase inhibitors.

(d) A pharmaceutical combination that is (i) a Compound of Formula (I) and ii) a therapeutic compound metabolized by CYP3A4 that is an anti-HIV drug; wherein the Compound of Formula (I) and the therapeutic compound metabolized by CYP3A4 are each employed in an amount that renders the combination effective for inhibiting HIV replication, or
5 for treating HIV infection and/or reducing the likelihood or severity of symptoms of HIV infection.

(e) The combination of (d), wherein the therapeutic compound metabolized by CYP3A4 is selected from the group consisting of HIV protease inhibitors, HIV integrase inhibitors, nucleoside reverse transcriptase inhibitors and non-nucleoside reverse-transcriptase
10 inhibitors.

(f) A method of inhibiting HIV replication in a subject in need thereof which comprises administering to the subject: (i) a Compound of Formula (I) and (ii) one or more anti-HIV drugs, wherein the amounts of the Compound of Formula (I) and the anti-HIV drug(s) are together effective to inhibit HIV replication.

(g) A method of treating HIV infection and/or reducing the likelihood or severity of symptoms of HIV infection in a subject in need thereof which comprises administering to the subject (i) a Compound of Formula (I) and (ii) one or more anti-HIV drugs, wherein the amounts of the Compound of Formula (I) and the anti-HIV drug(s) are together effective to treat HIV infection.
15

(h) The method of (h), wherein the anti-HIV drug(s) are an selected from the group consisting of HIV protease inhibitors, HIV integrase inhibitors, nucleoside reverse transcriptase inhibitors and non-nucleoside reverse-transcriptase inhibitors.
20

(i) A method of inhibiting HIV replication in a subject in need thereof which comprises administering to the subject the pharmaceutical composition of (c) or the combination of (d) or (e).
25

(j) A method of treating HIV infection and/or reducing the likelihood or severity of symptoms of HIV infection in a subject in need thereof which comprises administering to the subject the pharmaceutical composition of (b) or (c) or the combination of (d) or (e).
30

Additional embodiments of the invention include the pharmaceutical compositions, combinations and methods set forth in (a)-(j) above and the uses set forth in the preceding paragraph, wherein the compound of the present invention employed therein is a compound of one of the embodiments, aspects, classes, sub-classes, or features of the compounds described above. In all of these embodiments, the compound may optionally be used

in the form of a pharmaceutically acceptable salt or hydrate as appropriate. It is understood that references to compounds would include the compound in its present form as well as in different forms, such as polymorphs, solvates and hydrates, as applicable.

It is further to be understood that the embodiments of compositions and methods provided as (a) through (j) above are understood to include all embodiments of the compounds, including such embodiments as result from combinations of embodiments.

The Compounds of Formula (I) may be referred to herein by chemical structure and/or by chemical name. In the instance that both the structure and the name of a Compound of Formula (I) are provided and a discrepancy is found to exist between the chemical structure and the corresponding chemical name, it is understood that the chemical structure will predominate.

Non-limiting examples of the Compounds of Formula (I) include compounds 1-72 as set forth below, and pharmaceutically acceptable salts thereof.

Definitions and Abbreviations

The terms used herein have their ordinary meaning and the meaning of such terms is independent at each occurrence thereof. That notwithstanding and except where stated otherwise, the following definitions apply throughout the specification and claims. Chemical names, common names, and chemical structures may be used interchangeably to describe the same structure. If a chemical compound is referred to using both a chemical structure and a chemical name and an ambiguity exists between the structure and the name, the structure predominates. These definitions apply regardless of whether a term is used by itself or in combination with other terms, unless otherwise indicated. Hence, the definition of "alkyl" applies to "alkyl" as well as the "alkyl" portions of "hydroxyalkyl," "haloalkyl," "-O-alkyl," etc...

As used herein, and throughout this disclosure, the following terms, unless otherwise indicated, shall be understood to have the following meanings:

A "subject" is a human or non-human mammal. In one embodiment, a subject is a human. In another embodiment, a subject is a primate. In another embodiment, a subject is a monkey. In still another embodiment, the subject is a dog, cat, horse, pig, hamster or other companion animal.

The term "effective amount" as used herein, refers to: (i) an amount administered of a Compound of Formula (I), or pharmaceutically acceptable salt thereof, that is effective for inhibiting CYP3A4 in a subject, (ii) the amounts administered of each of a combination of: (A) a Compound of Formula (I), or pharmaceutically acceptable salt thereof, and (B) a therapeutic compound metabolized by CYP3A4 wherein the amounts administered are together effective in

producing the desired therapeutic, ameliorative, inhibitory or preventative effect when administered to a subject. In one embodiment the patient is suffering from HIV infection or AIDS and the therapeutic compound is an anti-HIV agent. In the combination therapies of the present invention, an effective amount can refer to each individual agent or to the combination as a whole, wherein the amounts of all agents administered are together effective, but wherein the component agent of the combination may not be present individually in an effective amount.

The term "preventing," as used herein with respect to an HIV viral infection or AIDS, refers to reducing the likelihood or severity of HIV infection or AIDS.

The term "alkyl," as used herein, refers to an aliphatic hydrocarbon group having one of its hydrogen atoms replaced with a bond. An alkyl group may be straight or branched and contain from about 1 to about 20 carbon atoms. In one embodiment, an alkyl group contains from about 1 to about 12 carbon atoms. In different embodiments, an alkyl group contains from 1 to 6 carbon atoms (C₁-C₆ alkyl) or from about 1 to about 4 carbon atoms (C₁-C₄ alkyl). Non-limiting examples of alkyl groups include methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, n-pentyl, neopentyl, isopentyl, n-hexyl, isohexyl and neohexyl. An alkyl group may be unsubstituted or substituted by one or more substituents which may be the same or different, each substituent being independently selected from the group consisting of halo, alkenyl, alkynyl, aryl, cycloalkyl, cyano, hydroxy, -O-alkyl, -O-aryl, -alkylene-O-alkyl, alkylthio, -NH₂, -NH(alkyl), -N(alkyl)₂, -NH(cycloalkyl), -O-C(O)-alkyl, -O-C(O)-aryl, -O-C(O)-cycloalkyl, -C(O)OH and -C(O)O-alkyl. In one embodiment, an alkyl group is linear. In another embodiment, an alkyl group is branched. Unless otherwise indicated, an alkyl group is unsubstituted.

The term "alkenyl," as used herein, refers to an aliphatic hydrocarbon group containing at least one carbon-carbon double bond and having one of its hydrogen atoms replaced with a bond. An alkenyl group may be straight or branched and contain from about 2 to about 15 carbon atoms. In one embodiment, an alkenyl group contains from about 2 to about 12 carbon atoms. In another embodiment, an alkenyl group contains from about 2 to about 6 carbon atoms. Non-limiting examples of alkenyl groups include ethenyl, propenyl, n-butenyl, 3-methylbut-2-enyl, n-pentenyl, octenyl and decenyl. An alkenyl group may be unsubstituted or substituted by one or more substituents which may be the same or different, each substituent being independently selected from the group consisting of halo, alkenyl, alkynyl, aryl, cycloalkyl, cyano, hydroxy, -O-alkyl, -O-aryl, -alkylene-O-alkyl, alkylthio, -NH₂, -NH(alkyl), -N(alkyl)₂, -NH(cycloalkyl), -O-C(O)-alkyl, -O-C(O)-aryl, -O-C(O)-cycloalkyl, -C(O)OH and -C(O)O-alkyl.

The term “C₂-C₆ alkenyl” refers to an alkenyl group having from 2 to 6 carbon atoms. Unless otherwise indicated, an alkenyl group is unsubstituted.

The term "alkynyl," as used herein, refers to an aliphatic hydrocarbon group containing at least one carbon-carbon triple bond and having one of its hydrogen atoms replaced with a bond. An alkynyl group may be straight or branched and contain from about 2 to about 15 carbon atoms. In one embodiment, an alkynyl group contains from about 2 to about 12 carbon atoms. In another embodiment, an alkynyl group contains from about 2 to about 6 carbon atoms. Non-limiting examples of alkynyl groups include ethynyl, propynyl, 2-butylnyl and 3-methylbutynyl. An alkynyl group may be unsubstituted or substituted by one or more substituents which may be the same or different, each substituent being independently selected from the group consisting of halo, alkenyl, alkynyl, aryl, cycloalkyl, cyano, hydroxy, -O-alkyl, -O-aryl, -alkylene-O-alkyl, alkylthio, -NH₂, -NH(alkyl), -N(alkyl)₂, -NH(cycloalkyl), -O-C(O)-alkyl, -O-C(O)-aryl, -O-C(O)-cycloalkyl, -C(O)OH and -C(O)O-alkyl. The term “C₂-C₆ alkynyl” refers to an alkynyl group having from 2 to 6 carbon atoms. Unless otherwise indicated, an alkynyl group is unsubstituted.

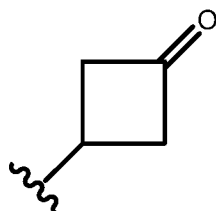
The term "alkylene," as used herein, refers to an alkyl group, as defined above, wherein one of the alkyl group's hydrogen atoms has been replaced with a bond. Non-limiting examples of alkylene groups include -CH₂-, -CH₂CH₂-, -CH₂CH₂CH₂-, -CH₂CH₂CH₂CH₂-, -CH(CH₃)CH₂CH₂-, -CH(CH₃)- and -CH₂CH(CH₃)CH₂-. In one embodiment, an alkylene group has from 1 to about 6 carbon atoms. In another embodiment, an alkylene group has from about 3 to about 5 carbon atoms. In another embodiment, an alkylene group is branched. In another embodiment, an alkylene group is linear. In one embodiment, an alkylene group is -CH₂-. The term “C₁-C₆ alkylene” refers to an alkylene group having from 1 to 6 carbon atoms. The term “C₃-C₅ alkylene” refers to an alkylene group having from 3 to 5 carbon atoms.

The term "alkenylene," as used herein, refers to an alkenyl group, as defined above, wherein one of the alkenyl group's hydrogen atoms has been replaced with a bond. Non-limiting examples of alkenylene groups include -CH=CH-, -CH=CHCH₂-, -CH₂CH=CH-, -CH₂CH=CHCH₂-, -CH=CHCH₂CH₂-, -CH₂CH₂CH=CH- and -CH(CH₃)CH=CH-. In one embodiment, an alkenylene group has from 2 to about 6 carbon atoms. In another embodiment, an alkenylene group has from about 3 to about 5 carbon atoms. In another embodiment, an alkenylene group is branched. In another embodiment, an alkenylene group is linear. The term “C₂-C₆ alkenylene” refers to an alkenylene group having from 2 to 6 carbon atoms. The term “C₃-C₅ alkenylene” refers to an alkenylene group having from 3 to 5 carbon atoms.

The term "aryl," as used herein, refers to an aromatic monocyclic or multicyclic ring system comprising from about 6 to about 14 carbon atoms. In one embodiment, an aryl group contains from about 6 to about 10 carbon atoms. An aryl group can be optionally substituted with one or more "ring system substituents" which may be the same or different, and are as defined herein. In one embodiment, an aryl group can be optionally fused to a cycloalkyl or cycloalkanoyl group. Non-limiting examples of aryl groups include phenyl and naphthyl. In one embodiment, an aryl group is phenyl. Unless otherwise indicated, an aryl group is unsubstituted.

The term "cycloalkyl," as used herein, refers to a non-aromatic mono- or multicyclic ring system comprising from about 3 to about 10 ring carbon atoms. In one embodiment, a cycloalkyl contains from about 5 to about 10 ring carbon atoms. In another embodiment, a cycloalkyl contains from about 3 to about 7 ring atoms. In another embodiment, a cycloalkyl contains from about 5 to about 6 ring atoms. The term "cycloalkyl" also encompasses a cycloalkyl group, as defined above, which is fused to an aryl (*e.g.*, benzene) or heteroaryl ring. Non-limiting examples of monocyclic cycloalkyls include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl and cyclooctyl. Non-limiting examples of multicyclic cycloalkyls include 1-decalinyl, norbornyl and adamantyl. A cycloalkyl group can be optionally substituted with one or more "ring system substituents" which may be the same or different, and are as defined herein. In one embodiment, a cycloalkyl group is unsubstituted.

The term "3 to 6-membered cycloalkyl" refers to a cycloalkyl group having from 3 to 6 ring carbon atoms. Unless otherwise indicated, a cycloalkyl group is unsubstituted. A ring carbon atom of a cycloalkyl group may be functionalized as a carbonyl group. An illustrative example of such a cycloalkyl group (also referred to herein as a "cycloalkanoyl" group) includes, but is not limited to, cyclobutanoyl:



The term "CYP3A," as used herein, refers to all the known members of the 3A subfamily of the cytochrome P450 superfamily of genes. CYP3A includes, but is not limited to CYP3A4, CYP3A5, CYP3A7 and CYP3A43. In one embodiment, the CYP3A gene is CYP3A4.

The term "halo," as used herein, means -F, -Cl, -Br or -I. In one embodiment, the halo group is F.

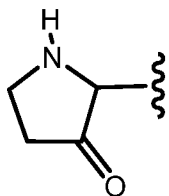
The term "haloalkyl," as used herein, refers to an alkyl group as defined above, wherein one or more of the alkyl group's hydrogen atoms has been replaced with a halogen. In one embodiment, a haloalkyl group has from 1 to 6 carbon atoms. In another embodiment, a haloalkyl group is substituted with from 1 to 3 F atoms. Non-limiting examples of haloalkyl groups include $-\text{CH}_2\text{F}$, $-\text{CHF}_2$, $-\text{CF}_3$, $-\text{CH}_2\text{Cl}$ and $-\text{CCl}_3$. The term "C₁-C₆ haloalkyl" refers to a haloalkyl group having from 1 to 6 carbon atoms.

The term "hydroxyalkyl," as used herein, refers to an alkyl group as defined above, wherein one or more of the alkyl group's hydrogen atoms have been replaced with an $-\text{OH}$ group. In one embodiment, a hydroxyalkyl group has from 1 to 6 carbon atoms. Non-limiting examples of hydroxyalkyl groups include $-\text{CH}_2\text{OH}$, $-\text{CH}_2\text{CH}_2\text{OH}$, $-\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ and $-\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$. The term "C₁-C₆ hydroxyalkyl" refers to a hydroxyalkyl group having from 1 to 6 carbon atoms.

The term "heteroaryl," as used herein, refers to an aromatic monocyclic or multicyclic ring system comprising about 5 to about 14 ring atoms, wherein from 1 to 4 of the ring atoms is independently O, N or S and the remaining ring atoms are carbon atoms. In one embodiment, a heteroaryl group has 5 to 10 ring atoms. In another embodiment, a heteroaryl group is monocyclic and has 5 or 6 ring atoms. In another embodiment, a heteroaryl group is bicyclic. A heteroaryl group can be optionally substituted by one or more "ring system substituents" which may be the same or different, and are as defined herein. A heteroaryl group is joined via a ring carbon atom, and any nitrogen atom of a heteroaryl can be optionally oxidized to the corresponding N-oxide. The term "heteroaryl" also encompasses a heteroaryl group, as defined above, which is fused to a benzene ring. Non-limiting examples of heteroaryls include pyridyl, pyrazinyl, furanyl, thienyl, pyrimidinyl, pyridone (including N-substituted pyridones), isoxazolyl, isothiazolyl, oxazolyl, oxadiazolyl, thiazolyl, pyrazolyl, furazanyl, pyrrolyl, triazolyl, 1,2,4-thiadiazolyl, pyrazinyl, pyridazinyl, quinoxalyl, phthalazinyl, oxindolyl, imidazo[1,2-a]pyridinyl, imidazo[2,1-b]thiazolyl, benzofurazanyl, indolyl, azaindolyl, benzimidazolyl, benzothienyl, quinolyl, imidazolyl, benzimidazolyl, thienopyridyl, quinazolinyl, thienopyrimidyl, pyrrolopyridyl, imidazopyridyl, isoquinolyl, benzoazaindolyl, 1,2,4-triazinyl, benzothiazolyl and the like, and all isomeric forms thereof. The term "heteroaryl" also refers to partially saturated heteroaryl moieties such as, for example, tetrahydroisoquinolyl, tetrahydroquinolyl and the like. In one embodiment, a heteroaryl group is a 5-membered heteroaryl. In another embodiment, a heteroaryl group is a 6-membered heteroaryl. In another embodiment, a heteroaryl group comprises a 5- to 6-membered heteroaryl group fused to a benzene ring. Unless otherwise indicated, a heteroaryl group is unsubstituted.

The term "heterocycloalkyl," as used herein, refers to a non-aromatic saturated monocyclic or multicyclic ring system comprising 3 to about 11 ring atoms, wherein from 1 to 4 of the ring atoms are independently O, S, N or Si, and the remainder of the ring atoms are carbon atoms. A heterocycloalkyl group can be joined via a ring carbon, ring silicon atom or ring nitrogen atom. In one embodiment, a heterocycloalkyl group is monocyclic and has from about 3 to about 7 ring atoms. In another embodiment, a heterocycloalkyl group is monocyclic has from about 4 to about 7 ring atoms. In another embodiment, the heterocycloalkyl group is bicyclic and has 9 or 10 ring atoms. In still another embodiment, a heterocycloalkyl group is monocyclic and has 5 or 6 ring atoms. In one embodiment, a heterocycloalkyl group is monocyclic. In another embodiment, a heterocycloalkyl group is bicyclic. There are no adjacent oxygen and/or sulfur atoms present in the ring system. Any -NH group in a heterocycloalkyl ring may exist protected such as, for example, as an -N(BOC), -N(Cbz), -N(Tos) group and the like; such protected heterocycloalkyl groups are considered part of this invention. The term "heterocycloalkyl" also encompasses a heterocycloalkyl group, as defined above, which is fused to an aryl (*e.g.*, benzene) or heteroaryl ring. A heterocycloalkyl group can be optionally substituted by one or more "ring system substituents" which may be the same or different, and are as defined herein. The nitrogen or sulfur atom of the heterocycloalkyl can be optionally oxidized to the corresponding N-oxide, S-oxide or S,S-dioxide. Non-limiting examples of monocyclic heterocycloalkyl rings include oxetanyl, piperidyl, pyrrolidinyl, piperazinyl, morpholinyl, thiomorpholinyl, thiazolidinyl, 1,4-dioxanyl, tetrahydrofuranyl, tetrahydrothiophenyl, delta-lactam, delta-lactone and the like, and all isomers thereof.

A ring carbon atom of a heterocycloalkyl group may be functionalized as a carbonyl group. An illustrative example of such a heterocycloalkyl group is:

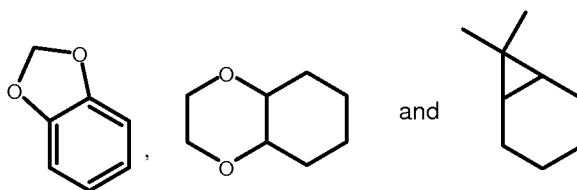


In one embodiment, a heterocycloalkyl group is a 5-membered monocyclic heterocycloalkyl. In another embodiment, a heterocycloalkyl group is a 6-membered monocyclic heterocycloalkyl. The term "3 to 6-membered monocyclic cycloalkyl" refers to a monocyclic heterocycloalkyl group having from 3 to 6 ring atoms. The term "4 to 6-membered monocyclic cycloalkyl" refers to a monocyclic heterocycloalkyl group having from 4 to 6 ring atoms. The term "7 to 11-membered bicyclic heterocycloalkyl" refers to a bicyclic

heterocycloalkyl group having from 7 to 11 ring atoms. Unless otherwise indicated, an heterocycloalkyl group is unsubstituted.

The term "HIV," as used herein, refers generically to all known species of the HIV virus, including, but not limited to, HIV-1 and HIV-2.

5 The term "ring system substituent," as used herein, refers to a substituent group attached to an aromatic or non-aromatic ring system which, for example, replaces an available hydrogen on the ring system. "Ring system substituent" may also mean a single moiety which simultaneously replaces two available hydrogens on two adjacent carbon atoms (one H on each carbon) on a ring system. Examples of such moiety are methylenedioxy, ethylenedioxy, -
10 C(CH₃)₂- and the like which form moieties such as, for example:



The term "substituted" means that one or more hydrogens on the designated atom is replaced with a selection from the indicated group, provided that the designated atom's normal valency under the existing circumstances is not exceeded, and that the substitution results in a
15 stable compound. Combinations of substituents and/or variables are permissible only if such combinations result in stable compounds. By "stable compound" or "stable structure" is meant a compound that is sufficiently robust to survive isolation to a useful degree of purity from a reaction mixture, and formulation into an efficacious therapeutic agent.

The term "in substantially purified form," as used herein, refers to the physical
20 state of a compound after the compound is isolated from a synthetic process (*e.g.*, from a reaction mixture), a natural source, or a combination thereof. The term "in substantially purified form," also refers to the physical state of a compound after the compound is obtained from a purification process or processes described herein or well-known to the skilled artisan (*e.g.*, chromatography, recrystallization and the like), in sufficient purity to be characterizable by
25 standard analytical techniques described herein or well-known to the skilled artisan.

It should also be noted that any carbon as well as heteroatom with unsatisfied valences in the text, schemes, examples and tables herein is assumed to have the sufficient number of hydrogen atom(s) to satisfy the valences.

When a functional group in a compound is termed "protected", this means that the
30 group is in modified form to preclude undesired side reactions at the protected site when the compound is subjected to a reaction. Suitable protecting groups will be recognized by those with

ordinary skill in the art as well as by reference to standard textbooks such as, for example, T. W. Greene *et al*, *Protective Groups in Organic Synthesis* (1991), Wiley, New York.

When any substituent or variable (*e.g.*, C₁-C₆ alkyl, R², R⁸, etc.) occurs more than one time in any constituent or in Formula (I), its definition on each occurrence is independent of its definition at every other occurrence, unless otherwise indicated.

As used herein, the term "composition" is intended to encompass a product comprising the specified ingredients in the specified amounts, as well as any product which results from combination of the specified ingredients in the specified amounts.

Prodrugs and solvates of the compounds of the invention are also contemplated herein. A discussion of prodrugs is provided in T. Higuchi and V. Stella, *Pro-drugs as Novel Delivery Systems* (1987) 14 of the A.C.S. Symposium Series, and in *Bioreversible Carriers in Drug Design*, (1987) Edward B. Roche, ed., American Pharmaceutical Association and Pergamon Press. The term "prodrug" means a compound (*e.g.*, a drug precursor) that is transformed *in vivo* to provide a Compound of Formula (I) or a pharmaceutically acceptable salt of the compound. The transformation may occur by various mechanisms (*e.g.*, by metabolic or chemical processes), such as, for example, through hydrolysis in blood.

For example, if a Compound of Formula (I) or a pharmaceutically acceptable salt, hydrate or solvate of the compound contains a carboxylic acid functional group, a prodrug can comprise an ester formed by the replacement of the hydrogen atom of the acid group with a group such as, for example, (C₁-C₈)alkyl, (C₂-C₁₂)alkanoyloxymethyl, 1-(alkanoyloxy)ethyl having from 4 to 9 carbon atoms, 1-methyl-1-(alkanoyloxy)-ethyl having from 5 to 10 carbon atoms, alkoxycarbonyloxymethyl having from 3 to 6 carbon atoms, 1-(alkoxycarbonyloxy)ethyl having from 4 to 7 carbon atoms, 1-methyl-1-(alkoxycarbonyloxy)ethyl having from 5 to 8 carbon atoms, N-(alkoxycarbonyl)aminomethyl having from 3 to 9 carbon atoms, 1-(N-(alkoxycarbonyl)amino)ethyl having from 4 to 10 carbon atoms, 3-phthalidyl, 4-crotonolactonyl, gamma-butyrolacton-4-yl, di-N,N-(C₁-C₂)alkylamino(C₂-C₃)alkyl (such as β-dimethylaminoethyl), carbamoyl-(C₁-C₂)alkyl, N,N-di (C₁-C₂)alkylcarbamoyl-(C₁-C₂)alkyl and piperidino-, pyrrolidino- or morpholino(C₂-C₃)alkyl, and the like. Similarly, if a Compound of Formula (I) contains an alcohol functional group, a prodrug can be formed by the replacement of one or more of the hydrogen atoms of the alcohol groups with a group such as, for example, (C₁-C₆)alkanoyloxymethyl, 1-((C₁-C₆)alkanoyloxy)ethyl, 1-methyl-1-((C₁-C₆)alkanoyloxy)ethyl, (C₁-C₆)alkoxycarbonyloxymethyl, N-(C₁-C₆)alkoxycarbonylaminomethyl, succinoyl, (C₁-C₆)alkanoyl, α-amino(C₁-C₄)alkyl, α-amino(C₁-C₄)alkylene-aryl, arylacyl and α-aminoacyl, or α-aminoacyl-α-aminoacyl, where each α-aminoacyl group is independently selected from the

naturally occurring L-amino acids, or glycosyl (the radical resulting from the removal of a hydroxyl group of the hemiacetal form of a carbohydrate) or a phosphate of structure PO_3M_2 where M is either sodium or potassium.

If a Compound of Formula (I) incorporates an amine functional group, a prodrug
 5 can be formed by the replacement of a hydrogen atom in the amine group with a group such as, for example, R-carbonyl-, RO-carbonyl-, NRR' -carbonyl- wherein R and R' are each independently $(\text{C}_1\text{-C}_{10})$ alkyl, $(\text{C}_3\text{-C}_7)$ cycloalkyl, benzyl, a natural α -aminoacyl, - $\text{C}(\text{OH})\text{C}(\text{O})\text{OY}^1$ wherein Y^1 is H, $(\text{C}_1\text{-C}_6)$ alkyl or benzyl, $-\text{C}(\text{OY}^2)\text{Y}^3$ wherein Y^2 is $(\text{C}_1\text{-C}_4)$ alkyl and Y^3 is $(\text{C}_1\text{-C}_6)$ alkyl; carboxy $(\text{C}_1\text{-C}_6)$ alkyl; amino $(\text{C}_1\text{-C}_4)$ alkyl or mono-N- or di-N,N- $(\text{C}_1\text{-C}_6)$ alkylaminoalkyl; $-\text{C}(\text{Y}^4)\text{Y}^5$ wherein Y^4 is H or methyl and Y^5 is mono-N- or di-N,N- $(\text{C}_1\text{-C}_6)$ alkylamino morpholino; piperidin-1-yl or pyrrolidin-1-yl, and the like.

Pharmaceutically acceptable esters of the present compounds include the following groups: (1) carboxylic acid esters obtained by esterification of the hydroxy group of a hydroxyl compound, in which the non-carbonyl moiety of the carboxylic acid portion of the ester
 15 grouping is selected from straight or branched chain alkyl (e.g., methyl, ethyl, n-propyl, isopropyl, t-butyl, sec-butyl or n-butyl), alkoxyalkyl (e.g., methoxymethyl), aralkyl (e.g., benzyl), aryloxyalkyl (for example, phenoxymethyl), aryl (e.g., phenyl optionally substituted with, for example, halogen, C_{1-4} alkyl, $-\text{O}-(\text{C}_{1-4}$ alkyl) or amino); (2) sulfonate esters, such as alkyl- or aralkylsulfonyl (for example, methanesulfonyl); (3) amino acid esters (e.g., L-valyl or L-isoleucyl); (4) phosphonate esters and (5) mono-, di- or triphosphate esters. The phosphate esters
 20 may be further esterified by, for example, a C_{1-20} alcohol or reactive derivative thereof, or by a 2,3-di (C_{6-24}) acyl glycerol.

One or more compounds of the invention may exist in unsolvated as well as solvated forms with pharmaceutically acceptable solvents such as water, ethanol, and the like,
 25 and it is intended that the invention embrace both solvated and unsolvated forms. "Solvate" means a physical association of a compound of this invention with one or more solvent molecules. This physical association involves varying degrees of ionic and covalent bonding, including hydrogen bonding. In certain instances the solvate will be capable of isolation, for example when one or more solvent molecules are incorporated in the crystal lattice of the
 30 crystalline solid. "Solvate" encompasses both solution-phase and isolatable solvates. Non-limiting examples of solvates include ethanolates, methanolates, and the like. A "hydrate" is a solvate wherein the solvent molecule is water.

One or more compounds of the invention may optionally be converted to a solvate. Preparation of solvates is generally known. Thus, for example, M. Caira *et al*, *J. Pharmaceutical*

Sci., 93(3), 601-611 (2004) describe the preparation of the solvates of the antifungal fluconazole in ethyl acetate as well as from water. Similar preparations of solvates, hemisolvate, hydrates and the like are described by E. C. van Tonder *et al*, *AAPS PharmSciTech* 5(1), article 12 (2004); and A. L. Bingham *et al*, *Chem. Commun.*, 603-604 (2001). A typical, non-limiting, process involves dissolving the inventive compound in desired amounts of the desired solvent (organic or water or mixtures thereof) at a higher than room temperature, and cooling the solution at a rate sufficient to form crystals which are then isolated by standard methods. Analytical techniques such as, for example IR spectroscopy, show the presence of the solvent (or water) in the crystals as a solvate (or hydrate).

The Compounds of Formula (I) can form salts which are also within the scope of this invention. Reference to a Compound of Formula (I) herein is understood to include reference to salts thereof, unless otherwise indicated. The term "salt(s)", as employed herein, denotes acidic salts formed with inorganic and/or organic acids, as well as basic salts formed with inorganic and/or organic bases. In addition, when a Compound of Formula (I) contains both a basic moiety, such as, but not limited to a pyridine or imidazole, and an acidic moiety, such as, but not limited to a carboxylic acid, zwitterions ("inner salts") may be formed and are included within the term "salt(s)" as used herein. In one embodiment, the salt is a pharmaceutically acceptable (*i.e.*, non-toxic, physiologically acceptable) salt. In another embodiment, the salt is other than a pharmaceutically acceptable salt. Salts of the Compounds of Formula (I) may be formed, for example, by reacting a Compound of Formula (I) with an amount of acid or base, such as an equivalent amount, in a medium such as one in which the salt precipitates or in an aqueous medium followed by lyophilization.

Exemplary acid addition salts include acetates, ascorbates, benzoates, benzenesulfonates, bisulfates, borates, butyrates, citrates, camphorates, camphorsulfonates, fumarates, hydrochlorides, hydrobromides, hydroiodides, lactates, maleates, methanesulfonates, naphthalenesulfonates, nitrates, oxalates, phosphates, propionates, salicylates, succinates, sulfates, tartarates, thiocyanates, toluenesulfonates (also known as tosylates) and the like. Additionally, acids which are generally considered suitable for the formation of pharmaceutically useful salts from basic pharmaceutical compounds are discussed, for example, by P. Stahl *et al*, Camille G. (eds.) *Handbook of Pharmaceutical Salts. Properties, Selection and Use*. (2002) Zurich: Wiley-VCH; S. Berge *et al*, *Journal of Pharmaceutical Sciences* (1977) 66(1) 1-19; P. Gould, *International J. of Pharmaceutics* (1986) 33 201-217; Anderson *et al*, *The Practice of Medicinal Chemistry* (1996), Academic Press, New York; and in *The Orange Book* (Food &

Drug Administration, Washington, D.C. on their website). These disclosures are incorporated herein by reference thereto.

Exemplary basic salts include ammonium salts, alkali metal salts such as sodium, lithium, and potassium salts, alkaline earth metal salts such as calcium and magnesium salts, salts with organic bases (for example, organic amines) such as dicyclohexylamine, t-butyl amine, choline, and salts with amino acids such as arginine, lysine and the like. Basic nitrogen-containing groups may be quarternized with agents such as lower alkyl halides (*e.g.*, methyl, ethyl, and butyl chlorides, bromides and iodides), dialkyl sulfates (*e.g.*, dimethyl, diethyl, and dibutyl sulfates), long chain halides (*e.g.*, decyl, lauryl, and stearyl chlorides, bromides and iodides), aralkyl halides (*e.g.*, benzyl and phenethyl bromides), and others.

All such acid salts and base salts are intended to be pharmaceutically acceptable salts within the scope of the invention and all acid and base salts are considered equivalent to the free forms of the corresponding compounds for purposes of the invention.

Diastereomeric mixtures can be separated into their individual diastereomers on the basis of their physical chemical differences by methods well-known to those skilled in the art, such as, for example, by chromatography and/or fractional crystallization. Enantiomers can be separated by converting the enantiomeric mixture into a diastereomeric mixture by reaction with an appropriate optically active compound (*e.g.*, chiral auxiliary such as a chiral alcohol or Mosher's acid chloride), separating the diastereomers and converting (*e.g.*, hydrolyzing) the individual diastereomers to the corresponding pure enantiomers. Stereochemically pure compounds may also be prepared by using chiral starting materials or by employing salt resolution techniques. Also, some of the Compounds of Formula (I) may be atropisomers (*e.g.*, substituted biaryls) and are considered as part of this invention. Enantiomers can also be directly separated using chiral chromatographic techniques.

It is also possible that the Compounds of Formula (I) may exist in different tautomeric forms, and all such forms are embraced within the scope of the invention. For example, all keto-enol and imine-enamine forms of the compounds are included in the invention.

All stereoisomers (for example, geometric isomers, optical isomers and the like) of the present compounds (including those of the salts, solvates, hydrates, esters and prodrugs of the compounds as well as the salts, solvates and esters of the prodrugs), such as those which may exist due to asymmetric carbons on various substituents, including enantiomeric forms (which may exist even in the absence of asymmetric carbons), rotameric forms, atropisomers, and diastereomeric forms, are contemplated within the scope of this invention. If a Compound of

Formula (I) incorporates a double bond or a fused ring, both the cis- and trans-forms, as well as mixtures, are embraced within the scope of the invention.

Individual stereoisomers of the compounds of the invention may, for example, be substantially free of other isomers, or may be admixed, for example, as racemates or with all other, or other selected, stereoisomers. The chiral centers of the present invention can have the S or R configuration as defined by the *IUPAC* 1974 Recommendations. The use of the terms "salt", "solvate", "ester", "prodrug" and the like, is intended to apply equally to the salt, solvate, ester and prodrug of enantiomers, stereoisomers, rotamers, tautomers, racemates or prodrugs of the inventive compounds.

In the Compounds of Formula (I), the atoms may exhibit their natural isotopic abundances, or one or more of the atoms may be artificially enriched in a particular isotope having the same atomic number, but an atomic mass or mass number different from the atomic mass or mass number predominantly found in nature. The present invention is meant to include all suitable isotopic variations of the compounds of generic Formula I. For example, different isotopic forms of hydrogen (H) include protium (^1H) and deuterium (^2H). Protium is the predominant hydrogen isotope found in nature. Enriching for deuterium may afford certain therapeutic advantages, such as increasing *in vivo* half-life or reducing dosage requirements, or may provide a compound useful as a standard for characterization of biological samples. Isotopically-enriched Compounds of Formula (I) can be prepared without undue experimentation by conventional techniques well known to those skilled in the art or by processes analogous to those described in the Schemes and Examples herein using appropriate isotopically-enriched reagents and/or intermediates. In one embodiment, a Compound of Formula (I) has one or more of its hydrogen atoms replaced with deuterium.

Polymorphic forms of the Compounds of Formula (I), and of the salts, solvates, hydrates, esters and prodrugs of the Compounds of Formula (I), are intended to be included in the present invention.

The following abbreviations are used below and have the following meanings: AcOH is acetic acid; Boc is *tert*-butyloxycarbonyl, $(\text{Boc})_2\text{O}$ or Boc_2O is Boc anhydride; *n*-BuLi is *n*-butyl lithium; *t*-BuNO₂ or *t*-BuONO is *tert*-butyl nitrite; Cbz is carboxybenzyl; DCM is dichloromethane; DIEA is *N,N*-diisopropylethylamine; DMF is dimethylformamide; DMSO is dimethylsulfoxide; EtOAc is ethyl acetate; EtOH is ethanol; Et₃N or TEA is triethylamine; HMPA is hexamethylphosphoramide; HOAc is acetic acid; HPLC is high-pressure liquid chromatography; KSCN is potassium thiocyanate; LCMS is liquid chromatography-mass spectrometry; LDA is lithium diisopropylamide; MeCN is acetonitrile;

MeI is iodomethane; MeOH is methanol; MS is mass spectroscopy; NaBH(OAc)₃ is sodium triacetoxy borohydride; NMR is nuclear magnetic resonance spectroscopy; PCy₃ is tricyclohexylphosphine; Pd(OAc)₂ is palladium(II) acetate; Pd₂(dba)₃ is tris dibenzylideneacetone dipalladium; PE is petroleum ether; PG is protecting group; Pd/C is palladium on carbon; Prep is preparative; rt is room temperature; TBAF is n-tetrabutylammonium fluoride; TFA is trifluoroacetic acid; TLC is thin-layer chromatography; TMSCN is trimethylsilyl cyanide; Ts is 4-toluenesulfonyl; THF is tetrahydrofuran; wt% is percentage by weight; and X-phos is 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl.

10

Uses of the Piperidine or Piperazine Imidazole and Triazole Derivatives

The compounds of the invention are useful in human and veterinary medicine for inhibiting CYP3A4. In addition, the compounds of the invention are useful for improving the pharmacokinetics of a therapeutic compound that is metabolized by CYP3A4.

15 The present invention provides novel compounds of Formula (I) that inhibit CYP3A. Uses of the compounds of Formula (I) described herein include inhibiting CYP3A, which may be useful for increasing the pharmacokinetics of compounds that are metabolized by CYP3A.

20 The present invention also encompasses the use of a Compound of Formula (I) for inhibiting CYP3A4 in a subject, said method comprising administering to said subject a Compound of Formula (I), or pharmaceutically acceptable salt thereof, in an amount that is effective to inhibit CYP3A4 in said subject.

The present invention also encompasses the use of a Compound of Formula (I) for the manufacture of a medicament useful for inhibiting CYP3A4 in a subject.

25

Inhibition of CYP3A4

30 The present invention provides methods for inhibiting CYP3A4 in a subject, said method comprising administering to said subject a Compound of Formula (I), or pharmaceutically acceptable salt thereof, in an amount that is effective to inhibit CYP3A4 in said subject.

The present invention also provides methods that may be, or are believed to be, useful for inhibiting other members of CYP3A in a subject, said method comprising administering to said subject a Compound of Formula I, or pharmaceutically acceptable salt thereof, in an amount that is effective to inhibit CYP3A in said subject. In one embodiment, the

CYP3A being inhibited is CYP3A5. In another embodiment, the CYP3A being inhibited is CYP3A7. In another embodiment, the CYP3A being inhibited is CYP3A4.

Improving the Pharmacokinetics of a Therapeutic Compound That is Metabolized by
CYP3A4

The present invention provides methods for improving the pharmacokinetics of a therapeutic compound that is metabolized by CYP3A4, comprising administering to a subject in need of such treatment an effective amount of a combination of said therapeutic compound and a Compound of Formula (I) or pharmaceutically acceptable salt thereof.

The present invention also provides methods that may be, or are believed to be, useful for improving the pharmacokinetics of a therapeutic compound that is metabolized by other members of CYP3A, comprising administering to a subject in need of such treatment an effective amount of a combination of said therapeutic compound and a Compound of Formula (I) or pharmaceutically acceptable salt thereof. In one embodiment, the therapeutic compound is metabolized by CYP3A5. In another embodiment, the therapeutic compound is metabolized by CYP3A7. In another embodiment, the therapeutic compound is metabolized by CYP3A43.

In one embodiment, the therapeutic compound whose pharmacokinetics are being improved is an anti-HIV drug.

In another embodiment, the therapeutic compound whose pharmacokinetics are being improved is an HIV protease inhibitor.

In still another embodiment, the therapeutic compound whose pharmacokinetics are being improved is an HIV integrase inhibitor.

In another embodiment, the therapeutic compound whose pharmacokinetics are being improved is a nucleoside reverse transcriptase inhibitor (nRTI).

In yet another embodiment, the therapeutic compound whose pharmacokinetics are being improved is a non-nucleoside reverse transcriptase inhibitor (nnRTI).

Treatment or Prevention of HIV Infection

The present invention provides methods for treating or preventing HIV infection in a subject comprising administering to the subject: (i) a Compound of Formula (I) or a pharmaceutically acceptable salt thereof and (ii) one or more anti-HIV drugs, wherein the amounts administered are together effective to treat or prevent HIV infection in said subject. In one embodiment, the present invention also provides methods for treating AIDS in a subject comprising administering to the subject: (i) a Compound of Formula (I) or a pharmaceutically

acceptable salt thereof and (ii) one or more anti-HIV drugs, wherein the amounts administered are together effective to treat AIDS in said subject.

The compositions and combinations of the present invention can be useful for treating a subject suffering from infection related to any HIV genotype.

5 In one embodiment, the HIV infection being treated is HIV-1.

In another embodiment, the HIV infection being treated is HIV-2.

In another embodiment, the HIV infection being treated has transformed into AIDS.

10 Combination Therapy

When administering a combination of a Compound of Formula (I) and one or more anti-HIV drugs to a subject, the Compound of Formula (I) and anti-HIV drug may be administered in any order such as, for example, sequentially, concurrently, together, simultaneously and the like. The amounts of the various actives in such combination therapy
15 may be different amounts (different dosage amounts) or same amounts (same dosage amounts). Thus, for non-limiting illustration purposes, a Compound of Formula (I) and the anti-HIV drug(s) may be present in fixed amounts (dosage amounts) in a single dosage unit (*e.g.*, a capsule, a tablet, and the like).

20 In one embodiment, the Compound of Formula (I) is administered during a time when the anti-HIV drug(s) exert their prophylactic or therapeutic effect, or *vice versa*.

In another embodiment, when administered in combination with a Compound of Formula (I), the anti-HIV drug(s) are administered in doses lower than the doses commonly employed when such agents are used as monotherapy for treating HIV infection. A lower dosage or less frequent administration of the the anti-HIV drug(s) may reduce the toxicity of therapy
25 without reducing the efficacy of therapy.

In one embodiment, the at least one Compound of Formula (I) and the anti-HIV drug(s) are present in the same composition. In one embodiment, this composition is suitable for oral administration. In another embodiment, this composition is suitable for intravenous administration. In another embodiment, this composition is suitable for subcutaneous
30 administration. In still another embodiment, this composition is suitable for parenteral administration.

In one embodiment, the administration of a Compound of Formula (I) and the anti-HIV drug(s) may inhibit the resistance of the HIV infection to one or more of the agents being administered.

Anti-HIV Drugs

An "anti-HIV drug," as defined herein, is any agent which is directly or indirectly effective in the inhibition of HIV reverse transcriptase or another enzyme required for HIV replication or infection, the treatment or prophylaxis of HIV infection, and/or the treatment, prophylaxis or delay in the onset or progression of AIDS. It is understood that an anti-HIV drug is effective in treating, preventing, or delaying the onset or progression of HIV infection or AIDS and/or diseases or conditions arising therefrom or associated therewith. For example, the Compounds of Formula (I) can be effectively administered, whether at periods of pre-exposure and/or post-exposure, in combination with effective amounts of one or more anti-HIV drugs selected from anti-HIV drugs, immunomodulators, antiinfectives, useful for treating HIV infection or AIDS. HIV antivirals are listed in Table A below.

Table A

Name	Type
abacavir, ABC, Ziagen®	nRTI
abacavir + lamivudine, Epzicom®	nRTI
abacavir + lamivudine + zidovudine, Trizivir®	nRTI
amprenavir, Agenerase®	PI
atazanavir, Reyataz®	PI
AZT, zidovudine, azidothymidine, Retrovir®	nRTI
CMX-157	nRTI
darunavir, Prezista®	PI
ddC, zalcitabine, dideoxycytidine, Hivid®	nRTI
ddI, didanosine, dideoxyinosine, Videx®	nRTI
ddI (enteric coated), Videx EC®	nRTI
delavirdine, DLV, Rescriptor®	nnRTI
Dolutegravir	PI
efavirenz, EFV, Sustiva®, Stocrin®	nnRTI
efavirenz + emtricitabine + tenofovir DF, Atripla®	nnRTI + nRTI
Elvitegravir	InI

emtricitabine, FTC, Emtriva®	nRTI
emtricitabine + tenofovir DF, Truvada®	nRTI
emvirine, Coactinon®	nnRTI
enfuvirtide, Fuzeon®	FI
enteric coated didanosine, Videx EC®	nRTI
etravirine, TMC-125	nnRTI
fosamprenavir calcium, Lexiva®	PI
indinavir, Crixivan®	PI
lamivudine, 3TC, Epivir®	nRTI
lamivudine + zidovudine, Combivir®	nRTI
lopinavir	PI
lopinavir + ritonavir, Kaletra®	PI
maraviroc, Selzentry®	EI
nelfinavir, Viracept®	PI
nevirapine, NVP, Viramune®	nnRTI
raltegravir, MK-0518, Isentress®	InI
rilpivirine, TMC-278	nnRTI
Rilpivirine + emtricitabine + tenofovir, Complera	nnRTI + nRTI
ritonavir, Norvir®	PI
saquinavir, Invirase®, Fortovase®	PI
stavudine, d4T, didehydrodeoxythymidine, Zerit®	nRTI
tenofovir DF (DF = disoproxil fumarate), TDF, Viread®	nRTI
tipranavir, Aptivus®	PI

EI = entry inhibitor; FI = fusion inhibitor; InI = integrase inhibitor; PI = protease inhibitor; nRTI = nucleoside reverse transcriptase inhibitor; nnRTI = non-nucleoside reverse transcriptase inhibitor. Some of the drugs listed in the table are used in a salt form; e.g., abacavir sulfate, indinavir sulfate, atazanavir sulfate, nelfinavir mesylate.

5

In one embodiment, the one or more anti-HIV drugs are selected from raltegravir, lamivudine, abacavir, ritonavir, dolutegravir, atazanavir, elvitegravir and lopinavir.

In still another embodiment, the compound of formula (I) is used in combination with an anti-HIV drug which is atazanavir, and optionally one or more additional anti-HIV drugs.

In another embodiment, the compound of formula (I) is used in combination with an anti-HIV drug which is darunavir, and optionally one or more additional anti-HIV drugs.

5 In another embodiment, the compound of formula (I) is used in combination with at least two anti-HIV drugs which are darunavir and raltegravir.

In another embodiment, the compound of formula (I) is used in combination with at least two anti-HIV drugs which are atazanavir and raltegravir.

10 In still another embodiment, the compound of formula (I) is used in combination with at least two anti-HIV drugs which are ritonavir and lopinavir.

In another embodiment, the compound of formula (I) is used in combination with at least three anti-HIV drug which are lopinavir, ritonavir and raltegravir.

In one embodiment, the present invention provides pharmaceutical compositions comprising (i) a compound of formula (I) or a pharmaceutically acceptable salt thereof; (ii) a
15 pharmaceutically acceptable carrier; and (iii) one or more additional anti-HIV drugs selected from lamivudine, abacavir, ritonavir and lopinavir, or a pharmaceutically acceptable salt thereof, wherein the amounts present of components (i) and (iii) are together effective for the treatment or prophylaxis of infection by HIV or for the treatment, prophylaxis, or delay in the onset or progression of AIDS in the subject in need thereof.

20 In another embodiment, the present invention provides a method for the treatment or prophylaxis of infection by HIV or for the treatment, prophylaxis, or delay in the onset or progression of AIDS in a subject in need thereof, which comprises administering to the subject (i) a compound of formula (I) or a pharmaceutically acceptable salt thereof and (ii) one or more additional anti-HIV drugs selected from raltegravir, lamivudine, abacavir, atazanavir, darunavir,
25 ritonavir and lopinavir, or a pharmaceutically acceptable salt thereof, wherein the amounts administered of components (i) and (ii) are together effective for the treatment or prophylaxis of infection by HIV or for the treatment, prophylaxis, or delay in the onset or progression of AIDS in the subject in need thereof.

It is understood that the scope of combinations of the compounds of this invention
30 with anti-HIV drugs is not limited to the HIV antivirals listed in Table A, but includes in principle any combination with any drug or pharmaceutical composition useful for the treatment or prophylaxis of AIDS. The anti-HIV drugs and other agents will typically be employed in these combinations in their conventional dosage ranges and regimens as reported in the art, including, for example, the dosages described in the Physicians' Desk Reference, Thomson PDR,

Thomson PDR, 57th edition (2003), the 58th edition (2004), the 59th edition (2005), and the like. The dosage ranges for a compound of the invention in these combinations are the same as those set forth above.

The doses and dosage regimen of the other agents used in the combination therapies of the present invention for the treatment or prevention of HIV infection can be determined by the attending clinician, taking into consideration the approved doses and dosage regimen in the package insert; the age, sex and general health of the subject; and the type and severity of the viral infection or related disease or disorder. When administered in combination, the Compound(s) of Formula (I) and the other agent(s) can be administered simultaneously (*i.e.*, in the same composition or in separate compositions one right after the other) or sequentially. This is particularly useful when the components of the combination are given on different dosing schedules, *e.g.*, one component is administered once daily and another component is administered every six hours, or when the preferred pharmaceutical compositions are different, *e.g.*, one is a tablet and one is a capsule. A kit comprising the separate dosage forms is therefore advantageous.

Compositions and Administration

Due to their activity, the Compounds of Formula (I) are useful in veterinary and human medicine. As described above, the Compounds of Formula (I) are useful for: inhibiting CYP3A4; improving the pharmacokinetics of a therapeutic compound that is metabolized by CYP3A4; and in combination with one or more anti-HIV agents for treating or preventing HIV infection in a subject in need thereof.

When administered to a subject, the Compounds of Formula (I) can be administered as a component of a composition that comprises a pharmaceutically acceptable carrier or vehicle. The present invention provides pharmaceutical compositions comprising an effective amount of at least one Compound of Formula (I) and a pharmaceutically acceptable carrier. In the pharmaceutical compositions and methods of the present invention, the active ingredients will typically be administered in admixture with suitable carrier materials suitably selected with respect to the intended form of administration, *e.g.*, oral tablets, capsules (either solid-filled, semi-solid filled or liquid filled), powders for constitution, oral gels, elixirs, dispersible granules, syrups, suspensions, and the like, and consistent with conventional pharmaceutical practices. For example, for oral administration in the form of tablets or capsules, the active drug component may be combined with any oral non-toxic pharmaceutically acceptable inert carrier, such as lactose, starch, sucrose, cellulose, magnesium stearate, dicalcium

phosphate, calcium sulfate, talc, mannitol, ethyl alcohol (liquid forms) and the like. Solid form preparations include powders, tablets, dispersible granules, capsules, cachets and suppositories. Powders and tablets may be comprised of from about 0.5 to about 95 percent inventive composition. Tablets, powders, cachets and capsules can be used as solid dosage forms suitable for oral administration.

Moreover, when desired or needed, suitable binders, lubricants, disintegrating agents and coloring agents may also be incorporated in the mixture. Suitable binders include starch, gelatin, natural sugars, corn sweeteners, natural and synthetic gums such as acacia, sodium alginate, carboxymethylcellulose, polyethylene glycol and waxes. Among the lubricants there may be mentioned for use in these dosage forms, boric acid, sodium benzoate, sodium acetate, sodium chloride, and the like. Disintegrants include starch, methylcellulose, guar gum, and the like. Sweetening and flavoring agents and preservatives may also be included where appropriate.

Liquid form preparations include solutions, suspensions and emulsions and may include water or water-propylene glycol solutions for parenteral injection.

Liquid form preparations may also include solutions for intranasal administration.

Also included are solid form preparations which are intended to be converted, shortly before use, to liquid form preparations for either oral or parenteral administration. Such liquid forms include solutions, suspensions and emulsions.

For preparing suppositories, a low melting wax such as a mixture of fatty acid glycerides or cocoa butter is first melted, and the active ingredient is dispersed homogeneously therein as by stirring. The molten homogeneous mixture is then poured into convenient sized molds, allowed to cool and thereby solidify.

Additionally, the compositions of the present invention may be formulated in sustained release form to provide the rate controlled release of any one or more of the components or active ingredients to optimize therapeutic effects, *e.g.*, antiviral activity and the like. Suitable dosage forms for sustained release include layered tablets containing layers of varying disintegration rates or controlled release polymeric matrices impregnated with the active components and shaped in tablet form or capsules containing such impregnated or encapsulated porous polymeric matrices.

In one embodiment, the Compounds of Formula (I) are administered orally.

In another embodiment, the Compounds of Formula (I) are administered intravenously.

In one embodiment, the present invention provides compositions comprising a Compound of Formula (I) or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

In one embodiment, a pharmaceutical preparation comprising at least one
5 Compounds of Formula (I) is in unit dosage form. In such form, the preparation is subdivided into unit doses containing effective amounts of the active components.

Compositions can be prepared according to conventional mixing, granulating or coating methods, respectively, and the present compositions can contain, in one embodiment, from about 0.1% to about 99% of the Compound(s) of Formula (I) by weight or volume. In
10 various embodiments, the present compositions can contain, in one embodiment, from about 1% to about 70% or from about 5% to about 60% of the Compound(s) of Formula (I) by weight or volume.

The Compounds of Formula (I) can be administered orally in a dosage range of 0.001 to 1000 mg/kg of mammal (e.g., human) body weight per day in a single dose or in divided
15 doses. One dosage range is 0.01 to 500 mg/kg body weight per day orally in a single dose or in divided doses. Another dosage range is 0.1 to 100 mg/kg body weight per day orally in single or divided doses. For oral administration, the compositions can be provided in the form of tablets or capsules containing 1.0 to 500 milligrams of the active ingredient, particularly 1, 5, 10, 15, 20, 25, 50, 75, 100, 150, 200, 250, 300, 400, and 500 milligrams of the active ingredient for the
20 symptomatic adjustment of the dosage to the subject to be treated. The specific dose level and frequency of dosage for any particular subject may be varied and will depend upon a variety of factors including the activity of the specific compound employed, the metabolic stability and length of action of that compound, the age, body weight, general health, sex, diet, mode and time of administration, rate of excretion, drug combination, the severity of the particular condition,
25 and the host undergoing therapy.

For convenience, the total daily dosage may be divided and administered in portions during the day if desired. In one embodiment, the daily dosage is administered in one portion. In another embodiment, the total daily dosage is administered in two divided doses over a 24 hour period. In another embodiment, the total daily dosage is administered in three divided
30 doses over a 24 hour period. In still another embodiment, the total daily dosage is administered in four divided doses over a 24 hour period.

The amount and frequency of administration of the Compounds of Formula (I) will be regulated according to the judgment of the attending clinician considering such factors as age, condition and size of the subject as well as severity of the symptoms being treated. The

compositions of the invention can further comprise one or more additional therapeutic agents, selected from those listed above herein. Accordingly, in one embodiment, the present invention provides compositions comprising: (i) a Compound of Formula (I) or a pharmaceutically acceptable salt thereof; (ii) a therapeutic compound that is metabolized by CYP3A4; and (iii) a pharmaceutically acceptable carrier. In another embodiment, the present invention provides compositions comprising: (i) a Compound of Formula (I) or a pharmaceutically acceptable salt thereof; (ii) one or more anti-HIV drugs; and (iii) a pharmaceutically acceptable carrier, wherein the amounts in the composition are together effective to treat HIV infection.

In another embodiment, the present invention provides compositions comprising a Compound of Formula (I) or a pharmaceutically acceptable salt thereof, a pharmaceutically acceptable carrier, and one or more anti-HIV drugs, wherein said anti-HIV drugs are selected from raltegravir, lamivudine, abacavir, atazanavir, darunavir, lopinavir and ritonavir.

In still embodiment, the present invention provides compositions comprising a Compound of Formula (I) or a pharmaceutically acceptable salt thereof, a pharmaceutically acceptable carrier, and raltegravir.

Kits

In one aspect, the present invention provides a kit comprising a therapeutically effective amount of at least one Compound of Formula (I), or a pharmaceutically acceptable salt, solvate, ester or prodrug of said compound and a pharmaceutically acceptable carrier, vehicle or diluent.

In another aspect the present invention provides a kit comprising an amount of at least one Compound of Formula (I), or a pharmaceutically acceptable salt, solvate, ester or prodrug of said compound and a therapeutic compound that is metabolized by CYP3A4. In one embodiment, the Compounds of Formula (I) and the therapeutic compound that is metabolized by CYP3A4 are provided in the same container. In one embodiment, the Compounds of Formula (I) and the therapeutic compound that is metabolized by CYP3A4 are provided in separate containers.

In another aspect the present invention provides a kit comprising an amount of at least one Compound of Formula (I), or a pharmaceutically acceptable salt, solvate, ester or prodrug of said compound and an amount of at least one anti-HIV drug listed above, wherein the amounts of the two or more active ingredients result in a desired therapeutic effect. In one embodiment, the Compounds of Formula (I) and the one or more anti-HIV drugs are provided in

the same container. In one embodiment, the Compounds of Formula (I) and the one or more anti-HIV drugs are provided in separate containers.

Methods for Making the Compounds of Formula (I)

5 The Compounds of Formula (I) may be prepared from known or readily prepared starting materials, following methods known to one skilled in the art of organic synthesis. Methods useful for making the Compounds of Formula (I) are set forth in the Examples below. Alternative synthetic pathways and analogous structures will be apparent to those skilled in the art of organic synthesis.

10 One skilled in the art of organic synthesis will recognize that the synthesis of the Compounds of Formula (I) may require protection of certain functional groups (*i.e.*, derivatization for the purpose of chemical compatibility with a particular reaction condition). Suitable protecting groups for the various functional groups of these compounds and methods for their installation and removal are well known in the art of organic chemistry. A summary of
15 many of these methods can be found in Greene *et al.*, *Protective Groups in Organic Synthesis*, Wiley-Interscience, New York, (1999).

One skilled in the art of organic synthesis will also recognize that one route for the synthesis of the Compounds of Formula (I) may be more desirable depending on the choice of appendage substituents. Additionally, one skilled in the art will recognize that in some cases
20 the order of reactions may differ from that presented herein to avoid functional group incompatibilities and thus adjust the synthetic route accordingly.

The preparation of some intermediates useful for making the Compounds of Formula (I) have been described in the literature and in compendia such as "Comprehensive Heterocyclic Chemistry" editions I, II and III, published by Elsevier and edited by A.R. Katritzky & R. JK Taylor. Manipulation of the required substitution patterns have also been
25 described in the available chemical literature as summarized in compendia such as "Comprehensive Organic Chemistry" published by Elsevier and edited by DH R. Barton and W. D. Ollis; "Comprehensive Organic Functional Group Transformations" edited by edited by A.R. Katritzky & R. JK Taylor and "Comprehensive Organic Transformation" published by Wily-
30 CVH and edited by R. C. Larock.

The Compounds Formula (I) may contain one or more silicon atoms. The compounds contemplated in this invention in general can be prepared using the carba-analog methodology unless otherwise noted. A recent review of the synthesis of silicon containing compounds can be found in "Silicon Chemistry: from Atom to Extended Systems", Ed P. Jutzi

& U. Schubert; ISBN 978-3-527-30647-3. Preparation of silyl containing amino acids has been described. See Bolm *et al.*, *Angew. Chem. Int Ed.*, **39**:2289 (2000). Descriptions of improved cellular uptake (Giralt, J. Am. Chem. Soc., **128**:8479 (2006)) and reduced metabolic processing of silyl containing compounds have been described (Johansson *et al.*, *Drug Metabolism & Disposition*, **38**:73 (2009)).

The starting materials used and the intermediates prepared using the methods set forth in Schemes A-L may be isolated and purified if desired using conventional techniques, including but not limited to filtration, distillation, crystallization, chromatography and alike. Such materials can be characterized using conventional means, including physical constants and spectral data.

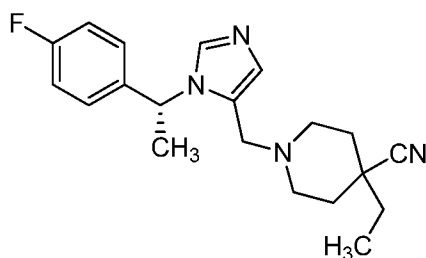
EXAMPLES

General Methods

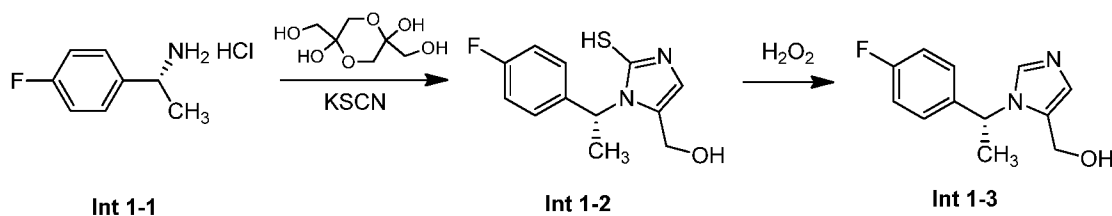
Solvents, reagents, and intermediates that are commercially available were used as received. Reagents and intermediates that are not commercially available were prepared in the manner as described below. ¹H NMR spectra were obtained on a Varian VNMR System 400 (400 MHz) and are reported as ppm downfield from Me₄Si with number of protons, multiplicities, and coupling constants in Hertz indicated parenthetically. Where LC/MS data are presented, analyses were performed using an Agilent 6110A MSD or an Applied Biosystems API-100 mass spectrometer and Shimadzu SCL-10A LC column: Altech platinum C18, 3 micron, 33 mm x 7mm ID; gradient flow: 0 minutes – 10% CH₃CN, 5 minutes – 95% CH₃CN, 5-7 minutes – 95% CH₃CN, 7 minutes – stop. The retention time and observed parent ion are given. Flash column chromatography was performed using pre-packed normal phase silica from Biotage, Inc. or bulk silica from Fisher Scientific. Unless otherwise indicated, column chromatography was performed using a gradient elution of hexanes/ethyl acetate, from 100% hexanes to 100% ethyl acetate.

EXAMPLE 1

(R)-4-Ethyl-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperidine-4-carbonitrile
(Compound 1)



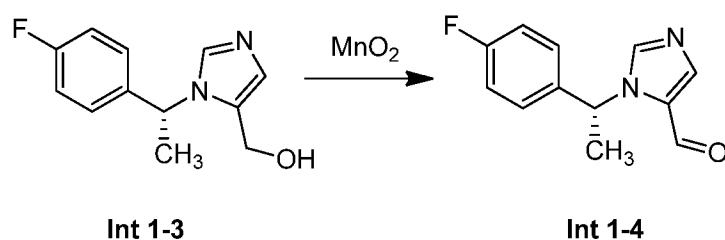
Step A – Preparation of Int 1-3



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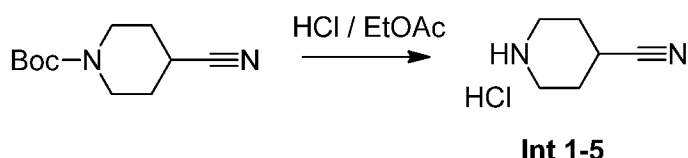
To a solution of compound Int 1-1 (200 g, 1.14 mol) in 2 L of 50% aqueous acetonitrile was added K_2CO_3 to adjust the solution to pH 8. Acetic acid (50 mL) was then added and the reaction was allowed to stir for 20 min before 1,3-dihydroxyacetone dimer (205 g, 1.14 mol) and KSCN (111 g, 1.14 mol) was added. The reaction mixture was allowed to stir at 9 °C for 5 hours when TLC (petroleum ether:EtOAc = 1:2) showed the reaction to be complete. The reaction mixture was then cooled to 0°C and H_2O_2 (388 mL, 30%, 3.42 mol) was added dropwise. The mixture was allowed to stir at 0°C for 1 hour, then the reaction mixture was quenched with saturated Na_2SO_3 at 0°C. Solid Na_2CO_3 was added to the mixture to adjust to pH 8~10 and the solid was filtered off. The remained aqueous filtrate was extracted with ethyl acetate and the combined organic extracts were dried over Na_2SO_4 , filtered and concentrated *in vacuo* to provide compound Int 1-3 (90 g), which was used in next step without further purification.

Step B – Preparation of Int 1-2



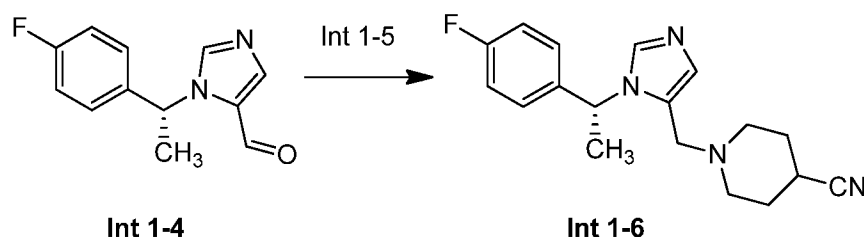
To a solution of compound Int 1-3 (90 g, 0.41 mmol) in dioxane (1 L) was added MnO_2 (107 g, 1.23 mol) and the mixture was allowed to stir at 80°C for 5 hours. The reaction mixture was filtered through Celite and the filtrate was concentrated *in vacuo*. The resulting residue was purified using column chromatography (1:1 petroleum ether / EtOAc) to provide 70 g (79%) of compound Int-1-4 as yellow oil.

Step C – Preparation of Int 1-5



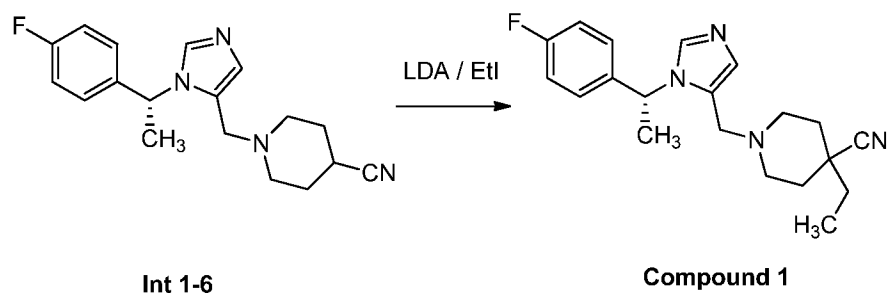
To a solution of N-Boc-4-cyanopiperidine (2.62 g, 12.4 mmol) in EtOAc (10 mL) was carefully added 10 mL HCl/EtOAc. The mixture was stirred at room temperature for 1 h. The solvent was removed by reducing pressure to afford 2.12 g white solid. The filtrate was concentrated to dryness which was used directly in the next step directly. ^1H NMR (CD_3OD) δ 3.40~3.32 (m, 2H), 3.23~3.17 (m, 3H), 2.26~2.21 (m, 2H), 2.10~2.01 (m, 2H).

Step D – Preparation of Int 1-6



To a stirred suspension of compound Int 1-5 (2.12g) in 30 mL of dry THF was added compound Int 1-4 (2.7 g, 12.4 mmol), excess $\text{Ti}(\text{OPr})_4$, MgSO_4 and Na_2CO_3 . The mixture was stirred at 70°C oil bath for 4 h. The mixture was cooled to room temperature, then to the stirring mixture suspension was added excess $\text{NaBH}(\text{OAc})_3$ and stirred for 2h. The mixture was filtrated and concentrated. The residue was purified by column to afford 3.3 g yellow solid. ^1H NMR (CDCl_3) δ 7.65 (s, 1H), 7.01~6.98 (m, 4H), 6.89 (s, 1H), 5.62 (q, $J=6.8$ Hz, 1H), 2.57~2.49 (m, 4H), 2.23~2.08 (m, 2H), 1.83 (d, $J=8.4$ Hz, 2H), 1.79 (d, $J=7.2$ Hz, 3H), 1.76~1.70 (m, 3H). MS (ESI) $m/z(\text{M}+1)$: 313.

Step E – Preparation of Compound 1



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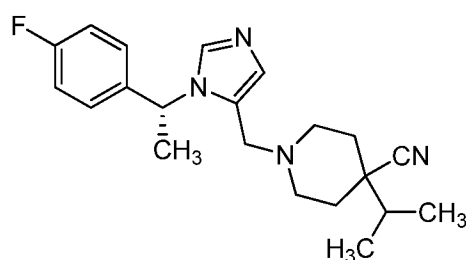
Compound Int 1-6 (0.322 g, 1.03 mmol) was dissolved in anhydrous THF (10 mL) and N₂ degassed for 5 times. The solution was cooled to -70°C then 0.9 mL LDA (1.5M in THF) was carefully injected to the solution. The mixture was stirred at this temperature for 0.5 h, then iodoethane (0.2162 g, 1.38 mmol) was injected. The mixture was stirred at this temperature for another 0.5 h, methanol was added to quench the reaction and the solvent was removed by reducing pressure. The residue was re-dissolved in 5 mL MeOH, filtrated and purified by pre-HPLC to afford 198 mg white solid. ¹H NMR (CD₃OD) δ 9.39 (s, 1H), 7.93 (s, 1H), 7.32 (s, 2H), 7.14 (s, 2H), 6.00 (s, 1H), 4.41~4.35 (m, 1H), 4.24 (d, *J*=13.6 Hz, 1H), 3.55 (s, 1H), 3.45 (s, 1H), 3.11 (d, *J*=10.4 Hz, 1H), 2.93 (d, *J*=9.2 Hz, 1H), 2.14 (t, *J*=15.6 Hz, 2H), 1.95~1.86 (m, 5H), 1.66 (d, *J*=6.4 Hz, 2H), 1.05 (s, 3H). MS (ESI) *m/z*(*M*+1): 341.

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EXAMPLE 2

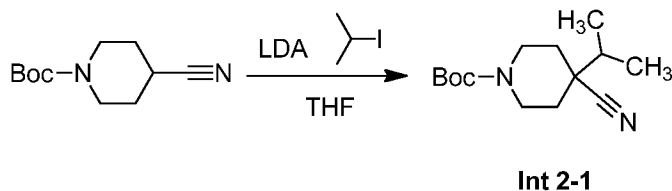
(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-isopropylpiperidine-4-carbonitrile (Compound 2)

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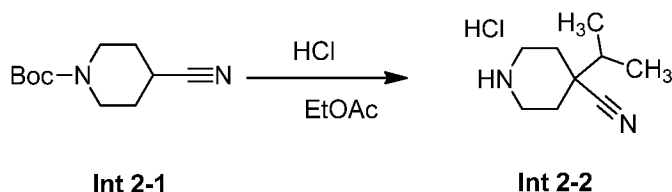
Step A – Preparation of Int 2-1

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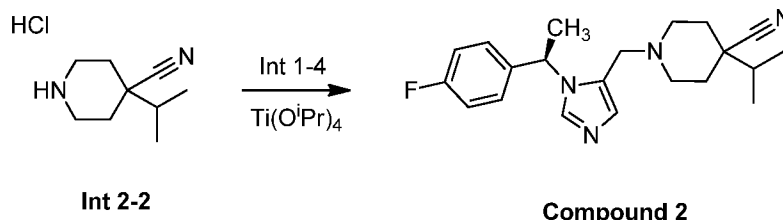
N-Boc-4-cyanopiperazine (1.46 g, 66.9 mmol) was dissolved in anhydrous THF (15 mL) and N₂ degassed for 5 times. The solution was cooled to -70°C then 5.5 mL LDA (1.5M in THF, 1.2 eq) was carefully injected to the solution. The mixture was stirred at this temperature for 0.5 h, then 2-iodopropane (1.36 g, 80.3 mmol) was injected. The mixture was stirred at this temperature for another 0.5 h, methanol was added to quench the reaction and the solvent was removed by reducing pressure. The residue was purified by column to afford 2.11 g of a white solid. ¹H NMR (CDCl₃) δ 4.20~4.02 (m, 2H), 2.98~2.76 (m, 2H), 1.88 (d, *J*=12.8 Hz, 2H), 1.58 (q, *J*=6.8 Hz, 1H), 1.39 (s, 9H), 1.32 (d, *J*=4.0 Hz, 1H), 1.29(d, *J*=4.4 Hz, 1H), 1.01(d, *J*=6.8 Hz, 6H).

Step B – Preparation of Int 2-2



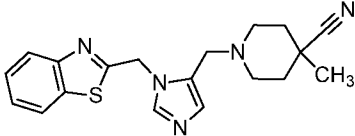
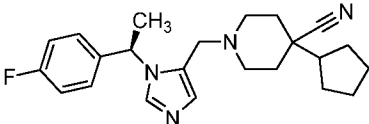
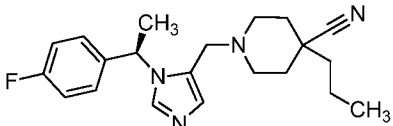
To a solution of compound Int 2-1 (0.52 g, 2.47 mmol) in EtOAc (5 mL) was carefully added 10 mL HCl/EtOAc. The mixture was stirred at room temperature for 1 h. The solvent was removed by reducing pressure to afford 0.50 g white solid. The filtrate was concentrated to dryness which was used directly in the next step directly. (Yield: 100%). ¹H-NMR (CD₃OD) δ 3.50 (d, *J*=13.2 Hz, 2H), 3.14 (dt, *J*₁=13.6Hz, *J*₂=2.8Hz, 2H), 2.25 (d, *J*=12.8 Hz, 2H), 1.85~1.75 (m, 3H), 1.09 (d, *J*=6.8 Hz, 6H).

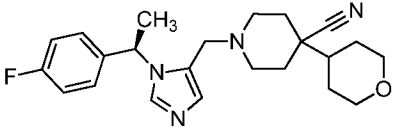
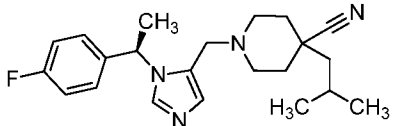
Step C – Preparation of Compound 2



- To a stirred suspension of compound Int 2-2 (0.5 g) in 15 mL of dry THF was added compound Int 1-4 (0.37 g, 1.69 mmol), excess $\text{Ti}(\text{O}^i\text{Pr})_4$, MgSO_4 and Na_2CO_3 . The mixture was stirred at 70°C oil bath for 4 h. The mixture was cooled to room temperature, then to the stirring mixture suspension was added excess $\text{NaBH}(\text{OAc})_3$ and stirred for 2h. The mixture was filtrated and concentrated. The residue was re-dissolved in 5 mL methanol filtrated and purified by pre-HPLC to afford white solid 357mg. Yield:54.2 %. MS (ESI) $m/z(M+1)$: 355. ^1H -NMR (CD_3OD) δ 9.36 (s, 1H), 7.88 (s, 2H), 7.32 (dd, $J_1=5.2$ Hz, $J_2=3.2$ Hz, 2H), 7.14 (t, $J=8.4$ Hz, 2H), 5.99 (dd, $J_1=6.0$ Hz, $J_2=7.2$ Hz, 1H), 4.28 (d, $J=15.2$ Hz, 1H), 4.12 (d, $J=15.2$ Hz, 1H), 3.48 (d, $J=11.6$ Hz, 1H), 3.40 (d, $J=12.0$ Hz, 1H), 2.99 (t, $J=12.8$ Hz, 1H), 2.82 (t, $J=12.4$ Hz, 1H), 2.14 (t, $J=12.8$ Hz, 2H), 1.94 (d, $J=6.8$ Hz, 3H), 1.82 (t, $J=13.2$ Hz, 2H), 1.78~1.68 (m, 1H), 1.04(d, $J=6.4$ Hz, 6H).
- The following compounds 3-8 were prepared using a protocol similar to that described in Examples 1 and 2 above.

Cmpd	Structure	IUPAC name	M+1	^1H NMR
3		(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidine-4-carbonitrile	327	CD_3OD : δ 9.22 (s, 1H), 7.62 (s, 1H), 7.30~7.27 (m, 2H), 7.16~7.12 (m, 2H), 6.98 (q, $J=6.8$ Hz, 1H), 3.76~3.73 (m, 1H), 3.59~3.55 (m, 1H), 2.95~2.83 (m, 2H), 2.46~2.36 (m, 2H), 1.91 (d, $J=6.8$ Hz, 5H), 1.60~1.41 (m, 2H), 1.34 (s, 3H).

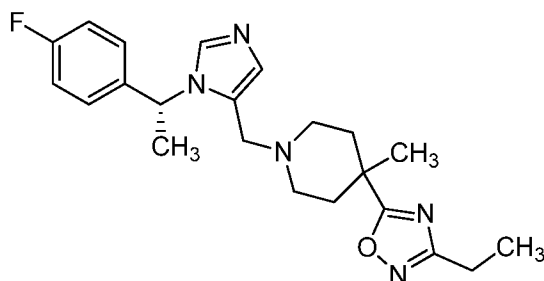
4		1-((1-(benzo[d]thiazol-2-ylmethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidine-4-carbonitrile	352	CD ₃ OD: δ 9.22 (s, 1H), 8.01 (d, $J=7.6$ Hz, 1H), 7.90 (d, $J=8.0$ Hz, 1H), 7.68 (s, 1H), 7.52 (t, $J=7.6$ Hz, 1H), 7.45 (t, $J=7.6$ Hz, 1H), 6.02 (m, 2H), 3.89 (m, 2H), 2.91~2.89 (m, 2H), 2.42~2.36 (m, 2H), 1.69 (d, $J=13.2$ Hz, 2H), 1.03 (m, 5H).
5		(R)-4-cyclopentyl-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperidine-4-carbonitrile	380	CD ₃ OD: δ 9.24 (d, $J=14.0$ Hz, 1H), 7.75~7.62 (m, 1H), 7.30~7.27 (m, 2H), 7.14 (t, $J=8.8$ Hz, 2H), 5.97 (q, $J=6.8$ Hz, 1H), 3.87~3.71 (m, 2H), 3.17~2.92 (m, 2H), 2.58~2.41 (m, 2H), 2.00~1.68 (m, 8H), 1.61~1.58 (m, 6H), 1.39 (s, 2H).
6		(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-propylpiperidine-4-carbonitrile	355	CD ₃ OD: δ 9.28 (s, 1H), 7.74 (s, 1H), 7.30 (dd, $J_1=5.2$ Hz, $J_2=2.4$ Hz, 2H), 7.14 (t, $J=8.4$ Hz, 2H), 5.97 (q, $J=6.8$ Hz, 1H), 3.99 (d, $J=14.8$ Hz, 1H), 3.82 (d, $J=14.8$ Hz, 1H), 3.13 (s, 2H), 2.68 (t, $J=12.0$ Hz, 1H), 2.59 (t, $J=12.0$ Hz, 1H), 2.00

				(d, $J=7.2$ Hz, 2H), 1.92 (d, $J=7.2$ Hz, 3H), 1.69~1.46 (m, 6H), 0.97 (t, $J=6.8$ Hz, 3H).
7		(R)-1-(((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-(tetrahydro-2H-pyran-4-yl)piperidine-4-carbonitrile	397	CD ₃ OD: δ 9.26 (s, 1H), 7.69 (s, 1H), 7.29 (s, 2H), 7.15 (t, $J=8.0$ Hz, 2H), 5.97 (d, $J=6.8$ Hz, 1H), 3.99 (d, $J=8.4$ Hz, 2H), 3.90 (d, $J=14.8$ Hz, 1H), 3.72 (d, $J=14.8$ Hz, 1H), 3.38 (t, $J=12.0$ Hz, 2H), 3.09 (dd, $J_1=12.0$ Hz, $J_2=8.8$ Hz, 2H), 2.53 (qu, $J=13.6$ Hz, 2H), 2.02 (d, $J=12.8$ Hz, 2H), 1.92 (d, $J=6.8$ Hz, 3H), 1.71 (d, $J=12.4$ Hz, 2H), 1.62 (t, $J=11.2$ Hz, 2H), 1.48 (t, $J=12.8$ Hz, 2H).
8		(R)-1-(((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-isobutylpiperidine-4-carbonitrile	369	CD ₃ OD: δ 9.22 (d, $J=9.6$ Hz, 1H), 7.64~7.59 (m, 1H), 7.27 (dd, $J_1=4.8$ Hz, $J_2=3.2$ Hz, 2H), 7.14 (t, $J=8.4$ Hz, 2H), 5.98 (q, $J=7.2$ Hz, 1H), 3.81~3.45 (m, 2H), 2.99~2.82 (m, 2H), 2.54~2.35 (m, 2H), 1.92~1.81 (m, 6H), 1.59~1.30 (m, 4H), 1.00 (d, $J=6.8$ Hz, 6H).

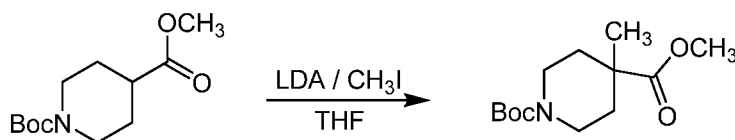
EXAMPLE 9

(R)-3-ethyl-5-(1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidin-4-yl)-1,2,4-oxadiazole (Compound 9)

5



Step A – Preparation of Int 9-1



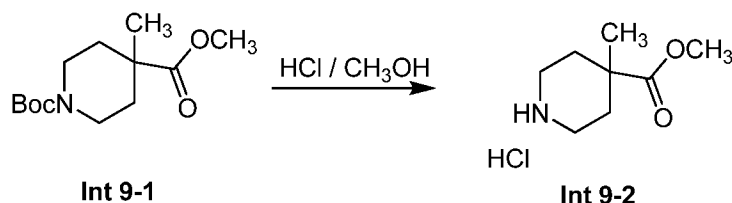
Int 9-1

10

To the solution of 2M LDA (39 mL, 77.12 mmol) in THF (150 mL) was added 1-tert-butyl 4-methyl piperidine-1,4-dicarboxylate (15 g, 61.73 mmol) at -70°C. The reaction mixture was stirred at -70 °C for 2 hours, then a solution of MeI (17 g, 122.2 mmol) in DMF (30 mL) was added. The mixture was allowed to warm to room temperature and stirred overnight. The mixture was poured into H₂O (100 mL) and extracted with EtOAc (100 mL × 3), the combined organic layer was washed with aqueous saturated sodium bicarbonate (100 mL) and brine (100 mL), dried over sodium sulfate and concentrated. The crude mixture was and purified with column chromatography (PE:EA=10:1) to give Int 9-1 (10 g, 63%). ¹H NMR (CDCl₃): δ 3.69-3.73 (m, 2H), 3.68 (s, 3H), 2.94-2.99 (m, 2H), 2.02-2.06 (m, 2H), 1.43 (s, 9H) 1.32-1.36 (m, 2H), 1.18 (s, 3H). MS (APCI): M/Z (M+1) 258.2.

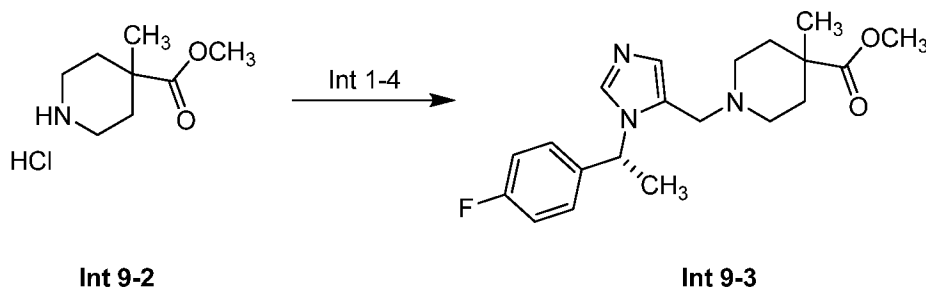
20

Step B – Preparation of Int 9-2



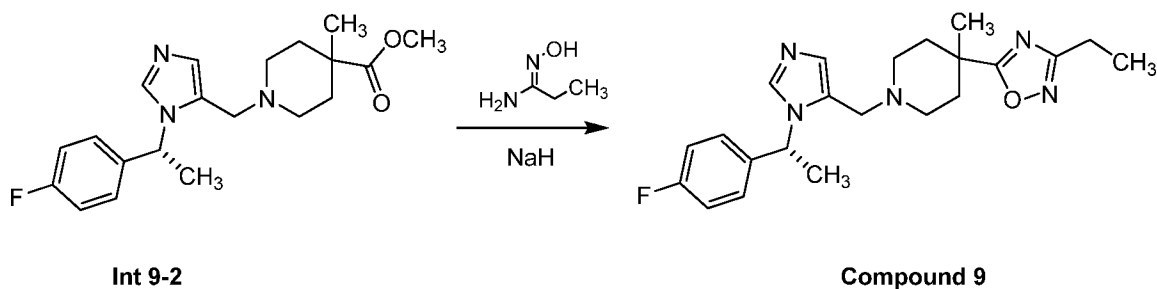
To the solution of Int 9-1 (7.0 g, 27.24 mmol) in 4M HCl/MeOH (20 mL) was heated to 60 °C overnight. The mixture was concentrated in vacuum to give Int 9-2 (4.6 g, 88%). ¹H NMR (CD₃OD): δ 3.74 (s, 3H), 3.25-3.36 (m, 2H), 2.94-3.02 (m, 2H), 2.52-2.60 (m, 2H), 1.61-1.70 (m, 2H) 1.27 (s, 3H). MS (APCI): M/Z (M+1) 158.2.

Step C – Preparation of Int 9-3



To the solution of Int 9-2 (1.0 g, 5.59 mmol) in THF (20 mL) was added NaHCO₃ (570 mg, 6.89 mmol), Int 1-4 (885 mg, 5.59 mmol) and Ti(EtO)₄ (3.14 g, 13.78 mmol). The reaction mixture was heated to 80 °C overnight, NaBH(AcO)₃ (1.95 g, 9.18 mmol) was added at room temperature and stirred for 4 hours. The mixture was poured into H₂O (200 mL) and extracted with EtOAc (200 mL × 3), the combined organic layer washed with aqueous saturated sodium bicarbonate (100 mL) and brine (100 mL), dried over sodium sulfate and concentrated. The crude mixture purified by column chromatography (PE:EA=10:1) to give Int 9-3 (1.0 g, 62%). ¹H NMR (CDCl₃): δ 7.58 (s, 1H), 6.91-7.01 (m, 4H), 6.81 (s, 1H), 6.65-6.67 (m, 1H), 4.93-4.96 (m, 1H) 3.61 (s, 1H), 3.11 (q, *J*=13.2Hz, 2H), 2.35-2.45 (m, 2H), 1.91-2.00 (m, 4H) 1.74 (d, *J*=7.6Hz, 3H) 1.14 (s, 3H) 1.06 (s, 3H). MS (APCI): M/Z (M+1) 360.2.

Step D – Preparation of Compound 9

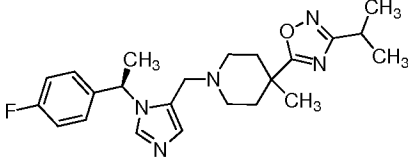


To a mixture of NaH (34 mg, 0.84mmol) in THF (3 mL) was added N'-hydroxypropionimidamide (74 mg, 0.84 mmol), the mixture was stirred at room temperature for 1 hour, and Int 9-2 (300 mg, 0.84 mmol) was added, the mixture was stirred at 100 °C for 12 hours. The mixture was concentrated and purified by *p*-HPLC to give compound 9 (60 mg, yield 18%). ¹H NMR (CD₃OD): δ 9.28 (s, 1H), 7.78 (s, 1H), 7.27-7.31 (m, 2H), 7.12-7.16 (m, 2H), 5.94 (q, *J*=7.0Hz, 1H), 4.10 (d, *J*=15.2Hz, 1H), 3.96 (d, *J*=14.8Hz, 1H), 3.18-3.19 (m, 2H), 2.72-2.77 (m, 4H), 2.35-2.42 (m, 2H), 1.92-1.98 (m, 5H), 1.39 (s, 3H), 1.30 (t, *J*=7.4Hz, 3H).

MS (APCI): *M/Z* (*M*+1) 398.2

The following compounds 10-11 were prepared using a protocol similar to that described in Example 9 above.

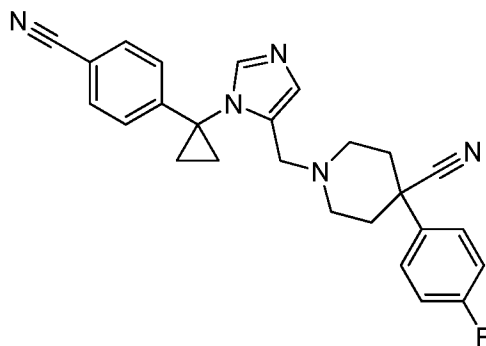
Cmpd	Structure	IUPAC name	<i>M</i> +1	¹ H NMR
10		(R)-5-((1-((1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidin-4-yl)-3-methyl-1,2,4-oxadiazole	384	CD ₃ OD: δ 9.21 (s, 1H), 7.73 (s, 1H), 7.19-7.22 (m, 2H), 7.05 (t, <i>J</i> =8.8Hz, 2H), 5.85 (q, <i>J</i> =6.8Hz, 1H), 4.00-4.02 (m, 2H), 3.14-3.21 (m, 2H), 2.79-2.84 (m, 1H), 2.65-2.67 (m, 1H), 2.28-2.35 (m, 5H), 1.83-1.93 (m, 5H), 1.38 (s, 3H).

11		(R)-5-(1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidin-4-yl)-3-isopropyl-1,2,4-oxadiazole	412	CD_3OD : δ 9.18 (s, 1H), 7.63 (s, 1H), 7.27-7.30 (m, 2H), 7.14 (t, $J=8.8\text{Hz}$, 2H), 5.96 (q, $J=7.0\text{Hz}$, 1H), 3.83 (d, $J=15.2\text{Hz}$, 1H), 3.67 (d, $J=15.2\text{Hz}$, 1H), 3.01-3.08 (m, 1H), 2.92-2.94 (m, 1H), 2.30-2.52 (m, 4H), 1.92 (d, $J=7.2\text{Hz}$, 3H), 1.74-1.84 (m, 2H), 1.35 (s, 3H), 1.31 (t, $J=7.2\text{Hz}$, 6H).
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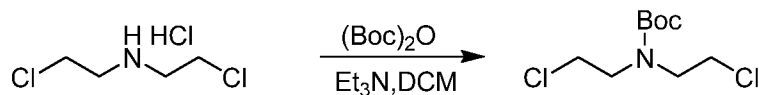
EXAMPLE 12

1-((1-(1-(4-cyanophenyl)cyclopropyl)-1H-imidazol-5-yl)methyl)-4-(4-fluorophenyl)piperidine-4-carbonitrile (Compound 12)



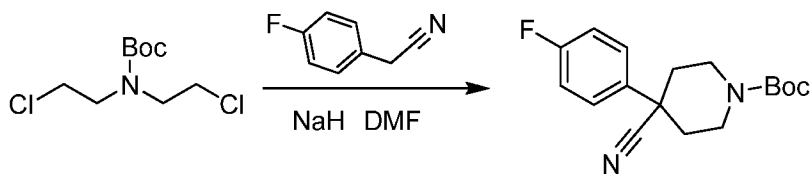
10

Step A – Preparation of Int 12-1

**Int 12-1**

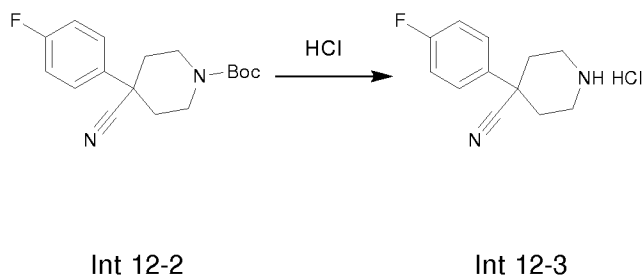
Bis(2-chloroethyl)amine hydrochloride (8.72 g, 48.8 mmol, 1eq) was dispersed in 150 mL DCM, then 3eq Et₃N (about 15 mL) was added to the stirring mixture. Excess (Boc)₂O was added to the stirring mixture in ice bath and then the mixture was stirred at room temperature for 1.5 h. The mixture was washed by water, dilute citric acid solution, saturated Na₂CO₃ solution in turn. The organic layer was dried over Na₂SO₄, filtrated and purified by column to afford 8.3 g oil residue. ¹H NMR (CDCl₃) δ 3.67~3.58 (m, 8H), 1.46 (s, 9H).

Step B – Preparation of Int 12-2

**Int 12-1****Int 12-2**

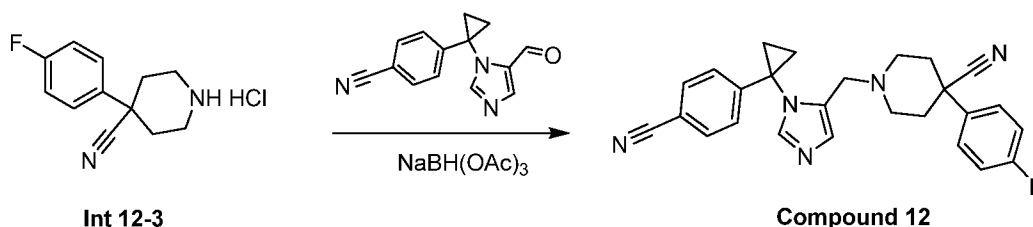
To a mixture solution of compound Int 12-1 (1.21 g, 5 mmol, 1 eq) and 4-fluorophenyl acetonitrile (675 mg, 5 mmol, 1 eq) in anhydrous DMF was added NaH (400 mg, 60% in mineral oil, 10 mmol, 2 eq) in portions in ice bath. Then the mixture was stirred in ice bath for 2h. The mixture was quenched by saturated NH₄Cl solution, extracted by EtOAc. The organic layer was dried, filtrated and concentrated. The residue was purified by column to afford 1.01g white solid. ¹H NMR (CDCl₃) δ 7.44~7.41 (m, 2H), 7.11~7.06 (m, 2H), 4.26(br, 2H), 3.16(br, 2H), 2.07(d, *J*=12.8Hz, 2H), 1.89(dt, *J*₁=4.0Hz, *J*₁=9.2 Hz, 2H), 1.46(s, 9H).

Step C – Preparation of Int 12-3



To a solution of Int 12-2 (0.35 g, 1.16 mmol) in EtOAc (5 mL) was carefully added 10 mL HCl/EtOAc. The mixture was stirred at room temperature for 1 h. The solvent was removed by reducing pressure to afford 0.28 g white solid. The filtrate was concentrated to dryness which was used directly in the next step directly. (Yield: 100%).

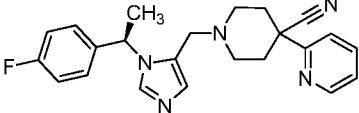
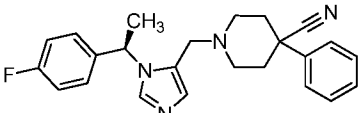
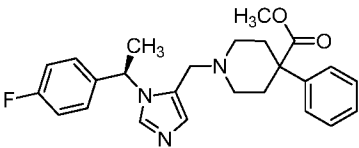
Step D – Preparation of Compound 12



To a stirred suspension of Int 12-3 (the residue of step C, 0.28 g) in 30 mL of dry THF was added compound 6 (0.2886 g, 1.21 mmol), excess $\text{Ti}(\text{OPr})_4$, MgSO_4 and Na_2CO_3 . The mixture was stirred at 70 °C for 4 h then the mixture was cooled to room temperature, then to the stirring mixture suspension was added excess $\text{NaBH}(\text{OAc})_3$ and stirred for 2h. The mixture was filtrated and concentrated. The residue was re-dissolved in 5 mL methanol and purified by pre-HPLC to afford white solid 302.5 mg. MS (ESI) $m/z(\text{M}+1)$: 426.0. ^1H NMR (CD_3OD) δ 9.37 (s, 1H), 7.71 (d, $J=8.4$ Hz, 1H), 7.66 (s, 1H), 7.32 (t, $J=6.4$ Hz, 2H), 7.14 (t, $J=8.4$ Hz, 2H), 7.09 (d, $J=8.8$ Hz, 2H), 3.71~3.66 (m, 2H), 2.88 (s, 2H), 2.43 (s, 2H), 2.00 (s, 2H), 1.87 (s, 4H), 1.35 (s, 2H).

The following compounds 13-15 were prepared using a protocol similar to that described in Example 12 above.

Cmpd	Structure	IUPAC name	M+1	^1H NMR
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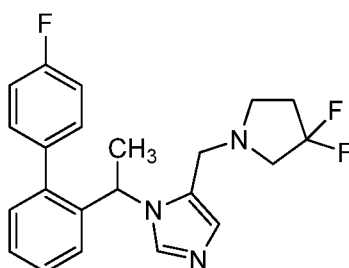
13		(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-(pyridin-2-yl)piperidine-4-carbonitrile	390	CD ₃ OD: δ 9.32 (s, 1H), 8.59 (s, 1H), 7.88 (t, $J=7.6$ Hz, 1H), 7.81 (s, 1H), 7.62 (d, $J=8.0$ Hz, 1H), 7.40~7.32 (m, 3H), 7.16 (t, $J=8.4$ Hz, 2H), 6.04 (d, $J=6.0$ Hz, 1H), 4.14~3.93 (m, 2H), 3.38~3.26 (m, 2H), 2.95~2.75 (m, 2H), 2.41~2.26 (m, 4H), 1.95 (d, $J=7.6$ Hz, 3H).
14		(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-phenylpiperidine-4-carbonitrile	389	CD ₃ OD: δ 9.28 (d, $J=0.8$ Hz, 1H), 7.67 (s, 1H), 7.47~7.39 (m, 4H), 7.36~7.28 (m, 3H), 7.14 (t, $J=8.8$ Hz, 2H), 6.01 (d, $J=6.8$ Hz, 1H), 3.83 (d, $J=14.4$ Hz, 1H), 3.61 (d, $J=14.8$ Hz, 1H), 3.09 (d, $J=11.6$ Hz, 1H), 2.95 (d, $J=12.4$ Hz, 1H), 2.61~2.55 (m, 2H), 2.14~2.03 (m, 3H), 1.93 (d, $J=6.8$ Hz, 3H), 1.89~1.84 (m, 1H).
15		(R)-methyl 1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-phenylpiperidine-4-carboxylate	422	CDCl ₃ : δ 8.60 (s, 1H), 7.73~7.67 (m, 1H), 7.29 (d, $J=6.8$ Hz, 2H), 7.20~7.19 (m, 2H), 7.10 (d, $J=7.2$ Hz, 4H), 5.94 (m, 1H), 3.85~3.81 (m, 2H), 3.64~3.63 (m, 2H),

				3.25 (m, 2H), 2.82~2.59 (m, 4H), 2.19 (m, 2H), 1.82 (d, J=6.8 Hz, 3H).
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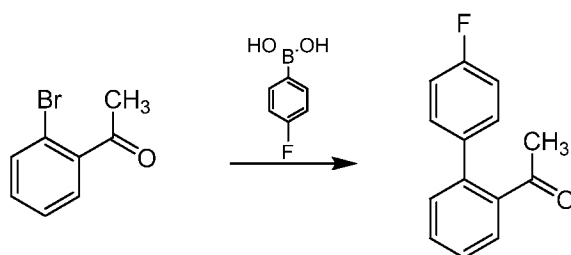
EXAMPLE 16

5-((3,3-difluoropyrrolidin-1-yl)methyl)-1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazole

(Compound 16)



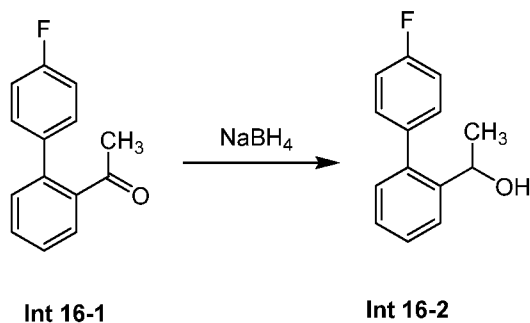
Step A – Preparation of Int 16-1



Int 16-1

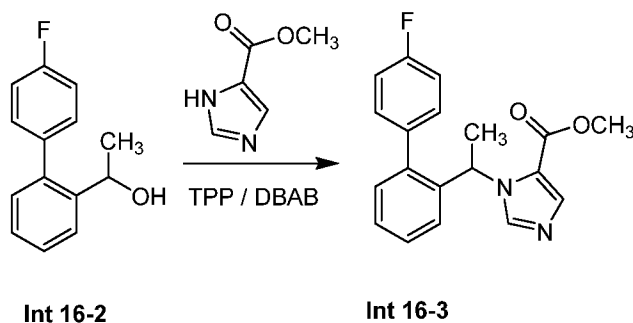
A degassed mixture of 2-bromoacetophenone (11 g, 54.9 mmol), phenylboronic acid (8.0 g, 65.9 mmol), Pd(dppf)Cl₂ (4 g, 5.49 mmol) and sodium carbonate (11.6 mg, 110 mmol) was added to DME (100 mL) and water (20 mL) and the mixture was heated to 80°C overnight. The reaction mixture was cooled and filtered and the filtrate was evaporated. The residue was purified by column chromatography (PE:EtOAc=100:1) to give Int 16-1 (8.0 g). ¹H NMR (CDCl₃): 7.47-7.54 (m, 2H), 7.38-7.42 (m, 1H), 7.24-7.34 (m, 3H), 7.08-7.12 (m, 2H), 2.03 (s, 1H). MS (APCI): M/Z (M+1) 215.1.

Step B – Preparation of Int 16-2



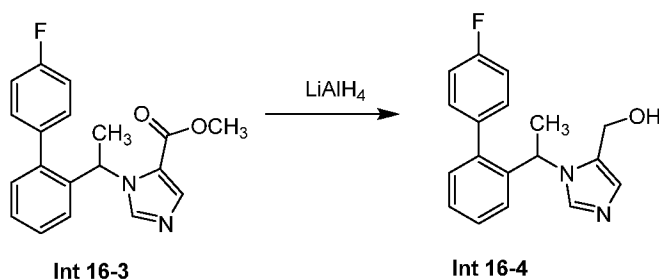
To a solution of Int 16-1 (4 g, 18.6 mmol) in MeOH (40 mL) was added NaBH₄ (0.825 g, 22.4 mmol) at 0°C. The mixture was stirred at room temperature for 30 mins and quenched with sat. NH₄Cl solution (20 mL), extracted with EtOAc (3x). The organic extracts were washed with water (2x) and brine (1x), then dried over Na₂SO₄. The solids were removed by filtration and the filtrate was concentrated to give Int 16-2 (3.5 g). ¹H NMR (CDCl₃): δ 7.64-7.66 (m, 1H), 7.38-7.42 (m, 1H), 7.24-7.31 (m, 3H), 7.15-7.17 (m, 1H), 7.06-7.11 (m, 2H), 4.09-4.94 (m, 1H), 1.39 (d, *J*= 6 Hz, 3H). MS (APCI): M/Z (M+1) 217.1.

Step C – Preparation of Int 16-3



15 To a solution of methyl 1H-imidazole-5-carboxylate (3.79 g, 30.09 mmol) and PPh₃ (9.46 g, 36.11 mmol) in THF (60 mL) was added Int 16-2 (6.5 g, 30.09 mmol) at -20 °C, then a solution of DBAD (8.3 g, 36.11 mmol) in THF (10 mL) was added. The mixture was stirred at this temperature for 2 hours. Water (30 mL) was added to the solution and extracted with EtOAc (3x). The combined organic phase was dried over MgSO₄ and concentrated. The residue was purified column chromatographic on silica gel (EtOAc) to give Int 16-3 (2 g, 20%). ¹H NMR (CDCl₃): δ 7.60 (s, 1H), 7.43 (s, 1H), 7.34-7.39 (m, 2H), 7.17-7.24 (m, 2H), 6.95-7.06 (m, 4H), 6.67-6.32 (m, 1H), 3.70 (s, 3H), 1.39 (d, *J* = 6.4 Hz, 3H). MS (APCI): *M/Z* (*M*+1) 325.1.

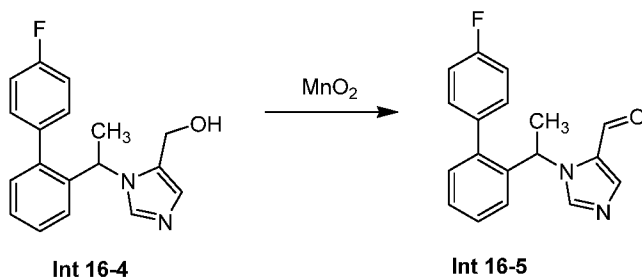
Step D – Preparation of Int 16-4



5

To a suspension of LiAlH_4 (117 mg, 3.088 mmol) in dry THF (15 mL) at 0°C was added a solution of Int 16-3 (500 mg, 1.54 mmol) in (5 mL) THF dropwise. The mixture was stirred at -78°C for 2 hours then quenched with water (0.3 mL), 15 % NaOH solution (0.3 mL) and water (2mL). The mixture was diluted with EtOAc (20 mL) and the organic phase was separated and dried over MgSO_4 . The filtrate was concentrated and the residue was purified by HPLC to give Int 16-4 (400 mg). ^1H NMR (CD_3OD): δ 8.80 (s, 1H), 7.34-7.48 (m, 9H), 5.80-5.86 (m, 1H), 4.18 (d, $J=14$ Hz, 1H), 3.88 (d, $J=14$ Hz, 1H), 1.88 (d, $J=7.2$ Hz, 3H). MS (APCI): M/Z ($M+1$) 297.1.

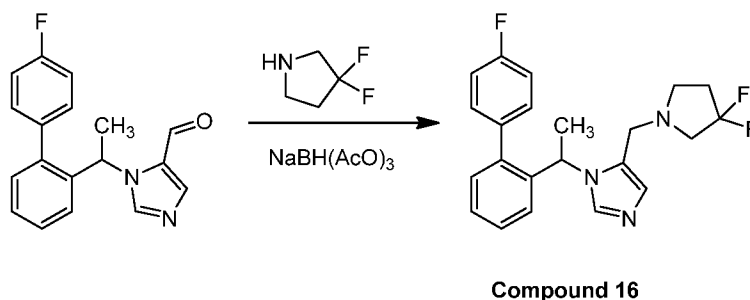
15 Step E – Preparation of Int 16-5



To a solution of Int 16-4 (500 mg, 1.68 mmol) in dioxane (10 mL) was added MnO_2 (1.46 mg, 16.83 mmol). The mixture was heated to reflux overnight then cooled and filtered. The filtrate was dried over MgSO_4 and concentrated to give Int 16-5 (400 mg) which was used into the next step without further purification. MS (APCI): M/Z ($M+1$) 295.1.

Step F – Preparation of Compound 16

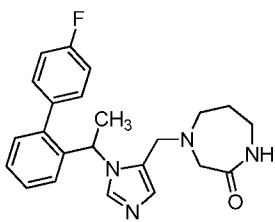
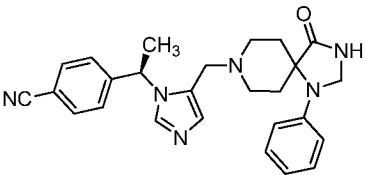
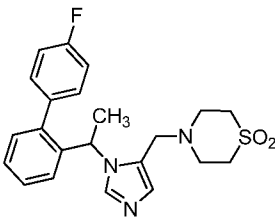
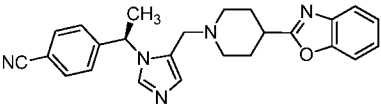
25

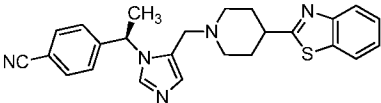


A mixture of Int 16-5 (150 mg, 0.51 mmol), NaBH(OAc)₃ (216 mg, 1.02 mmol), DIEA (130 mg, 1.02 mmol), and 3,3-difluoropyrrolidine (60 mg, 0.56 mmol) in DCM (5 mL) was stirred at room temperature overnight, the reaction mixture was concentrated and purified by HPLC to give Compound 16 (99 mg, 55.8%). ¹H NMR (CD₃OD) δ: 8.94 (s, 1H), 7.44~7.54 (m, 4H), 7.21-7.32 (m, 5H), 6.00 (q, J=6.8Hz, 1H), 3.31~3.34 (m, 2H), 2.52~2.80 (m, 4H), 2.14~2.25 (m, 2H), 1.84 (d, J=6.8Hz, 3H). MS (APCI): M/Z (M+1) 386.1.

- 10 The following compounds 17-22 were prepared using a protocol similar to that described in Example 16 above using a substituted cyclic amine and an appropriately substituted imidazole carboxaldehyde.

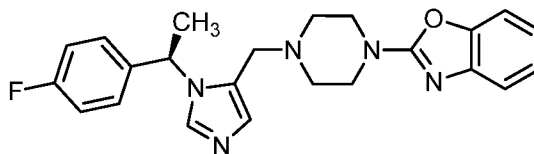
Cmpd	Structure	IUPAC name	M+1	¹ H NMR
17		1-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)pyrrolidin-3-ol	366	CD ₃ OD δ: 9.19 (d, J=5.2Hz, 1H), 7.78 (s, 1H), 7.38~7.46 (m, 4H), 7.25-7.32 (m, 4H), 5.78 (q, J=3.6Hz, 1H), 4.46 (s, 1H), 4.04~4.09 (m, 1H), 3.86~3.91 (m, 1H), 3.15~3.23 (m, 3H), 3.02~3.06 (m, 1H), 2.08~2.17 (m, 1H), 1.96~2.02 (m, 4H).

18		4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)-1,4-diazepan-2-one	393	CD ₃ OD δ 8.85 (s, 1H), 7.44~7.48 (m, 6H), 7.34 (s, 1H), 7.17~7.25 (m, 5H), 5.84 (q, J=6.8Hz, 1H), 3.20~3.33 (m, 5H), 2.97 (d, J=14.8Hz, 1H), 2.64~2.76 (m, 2H), 1.92 (d, J=6.8Hz, 3H), 1.58~1.61 (m, 2H).
19		(R)-4-(1-(5-((4-oxo-1-phenyl-1,3,8-triazaspiro[4.5]decan-8-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile		
20		4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)thiomorpholine 1,1-dioxide	414	CD ₃ OD δ: 7.46 (t, J=3.2Hz, 4H), 7.19~7.28 (m, 5H), 5.92 (q, J=6.8Hz, 1H), 3.29 (t, J=6.8Hz, 3H), 2.88~3.04 (m, 5H), 2.62~2.78 (m, 4H), 1.96 (d, J=6.8Hz, 3H).
21		(R)-4-(1-(5-((4-(benzo[d]oxazol-2-yl)piperidin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile	412	CD ₃ OD δ 8.10 (s, 1H), 7.72 (d, J=8.0 Hz, 2H), 7.63~7.58 (m, 2H), 7.34~7.30 (m, 4H), 6.97 (s, 1H), 5.87 (q, J=7.2 Hz, 1H), 3.50 (d, J=13.7 Hz, 1H), 3.25~3.22 (m,

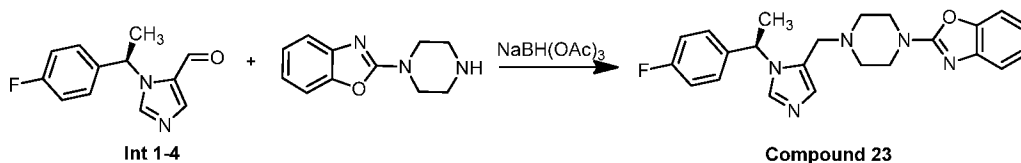
				1H), 2.90~2.87 (m, 2H), 2.67~2.63 (m, 1H), 2.11~1.93 (m, 3H), 1.89~1.87 (m, 4H), 1.77~1.64 (m, 1H), 1.41~1.38 (m, 1H).
22		(R)-4-(1-(5-((4-cyanophenyl)ethyl)-1H-imidazol-1-yl)methyl)-1H-imidazol-1-ylethyl)benzonitrile	428	CD ₃ OD δ : 9.40 (s, 1H), 7.95 (t, J=7.2 Hz, 2H), 7.92 (s, 1H), 7.78 (d, J=8.4 Hz, 2H), 7.51 (t, J=8.4 Hz, 1H), 7.45~7.40 (m, 3H), 6.07 (q, J=6.8 Hz, 1H), 4.30 (d, J=14.4 Hz, 1H), 4.07 (d, J=14.4 Hz, 1H), 3.52~3.39 (m, 3H), 3.05~3.00 (m, 2H), 2.36~2.31 (m, 2H), 2.12~2.00 (m, 2H), 1.98 (d, J=8.4 Hz, 3H).

EXAMPLE 23

- 5 (R)-2-(4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole
(Compound 23)



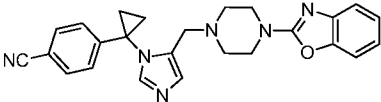
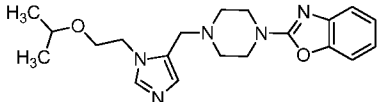
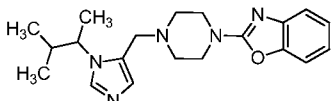
- 10 Step A – Preparation of Compound 23

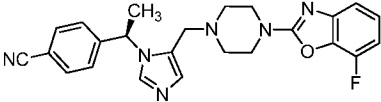
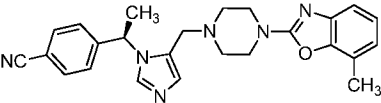
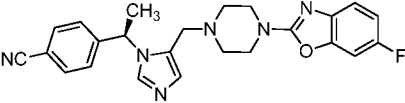


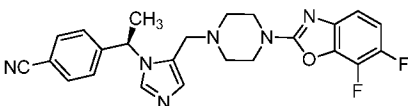
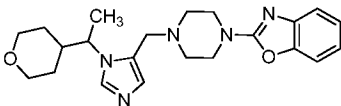
A mixture compound of compound Int 1-4 (100 mg, 0.49 mmol), and 2-(piperazin-1-yl)benzo[d]oxazole (107 mg, 0.49 mmol) in 1,2-dichloromethane was stirred at room temperature for 3h. NaBH(OAc)₃ (311 mg, 1047 mmol) was added and the mixture was stirred for 16 hours, diluted with H₂O and extracted with CH₂Cl₂ (3×5 mL). The combined organic extracts were washed with H₂O (3×5 mL) and brine, dried (Na₂SO₄) and concentrated. The residue was purified by HPLC to afford 50 mg of Compound 23. ¹H NMR (CD₃OD) δ 9.23 (s, 1H), 7.60 (s, 1H), 7.35~7.29 (m, 4H), 7.24~7.21 (m, 1H), 7.20~7.10 (m, 3H), 6.06 (d, *J*=6.8 Hz, 1H), 3.67~3.59 (m, 5H), 3.48 (d, *J*=14.8 Hz, 1H), 2.64~2.55 (m, 4H), 1.94 (d, *J*=6.8 Hz, 3H). MS (ESI) *m/z*(*M*+1): 406.

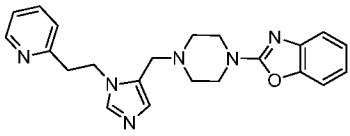
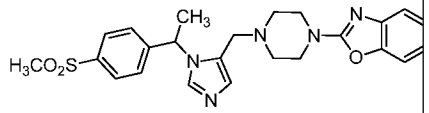
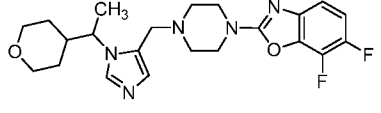
The following compounds 24-39 were prepared using a protocol similar to that described in Example 23 using a substituted piperazine and an appropriately substituted imidazole carboxaldehyde (prepared as illustrated in Example 1).

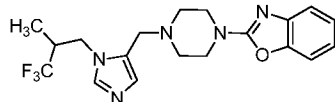
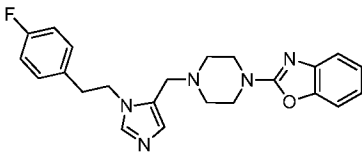
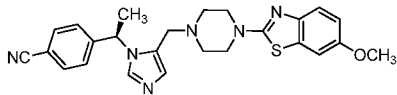
24		(R)-4-(1-(5-((4-(benzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-ylethyl)benzonitrile	413	CD ₃ OD δ: 9.34 (s, 1H), 7.74 (d, <i>J</i> =8.4 Hz, 2H), 7.67 (s, 1H), 7.43 (d, <i>J</i> =8.4 Hz, 2H), 7.36 (d, <i>J</i> =8.0 Hz, 1H), 7.24 (d, <i>J</i> =7.6 Hz, 1H), 7.17 (t, <i>J</i> =7.6 Hz, 1H), 7.12 (t, <i>J</i> =7.2 Hz, 1H), 6.12 (q, <i>J</i> =7.2 Hz, 1H), 3.76 (d, <i>J</i> =14.8 Hz, 1H), 3.78~3.62 (m, 2H), 3.53 (d, <i>J</i> =14.4 Hz, 1H), 1.97 (d, <i>J</i> =8.0 Hz, 3H).
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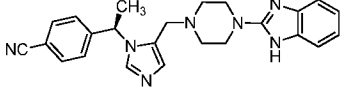
25		4-(1-(5-((4-(benzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)cyclopropyl)benzonitrile	425	CD ₃ OD δ 9.38 (s, 1H), 7.71 (d, <i>J</i> =8.4 Hz, 2H), 7.66 (s, 1H), 7.31 (d, <i>J</i> =8.0 Hz, 1H), 7.28 (d, <i>J</i> =7.2 Hz, 1H), 7.20 (t, <i>J</i> =7.6 Hz, 1H), 7.18~7.08 (m, 3H), 3.59 (s, 2H), 3.42~3.39 (m, 4H), 2.54~2.52 (m, 4H), 2.03 (s, 2H), 1.88~1.87 (s, 2H).
26		2-(4-((1-(2-isopropoxyethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole	370	CD ₃ OD δ 8.96 (s, 1H), 7.63 (s, 1H), 7.39 (d, <i>J</i> =8.0 Hz, 1H), 7.33 (d, <i>J</i> =7.2 Hz, 1H), 7.24 (t, <i>J</i> =7.6 Hz, 1H), 7.14 (t, <i>J</i> =8.0 Hz, 1H), 4.52 (t, <i>J</i> =5.2 Hz, 2H), 4.04 (s, 2H), 3.82~3.78 (m, 6H), 3.59~3.55 (m, 1H), 2.91 (t, <i>J</i> =5.2 Hz, 4H), 1.09 (d, <i>J</i> =6.0 Hz, 6H).
27		2-(4-((1-(3-methylbutan-2-yl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole	354	CD ₃ OD δ 9.17 (s, 1H), 7.61 (s, 1H), 7.38 (d, <i>J</i> =8.0 Hz, 1H), 7.32 (d, <i>J</i> =7.6 Hz, 1H), 7.24 (t, <i>J</i> =7.6 Hz, 1H), 7.14 (t, <i>J</i> =7.6 Hz, 1H), 4.51~4.44 (m, 1H), 3.90 (s, 2H), 3.78 (t, <i>J</i> =8.4 Hz, 4H), 2.84~2.83 (m, 4H), 2.20~2.11 (m, 1H), 1.56 (d, <i>J</i> =6.8 Hz, 3H),

				1.04 (d, J=6.8 Hz, 3H), 0.86 (d, J=6.8 Hz, 3H).
28		(R)-4-(1-(5-((4-(7-fluorobenzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile	431	CD ₃ OD δ 9.31 (s, 1H), 7.79 (d, J=8.4 Hz, 2H), 7.62 (s, 1H), 7.44 (d, J=8.0 Hz, 2H), 7.23~7.15 (m, 2H), 6.97~6.92 (m, 1H), 6.13 (q, J=7.2 Hz, 1H), 3.64 (d, J=14.4 Hz, 1H), 3.55~3.42 (m, 4H), 3.38 (d, J=14.8 Hz, 1H), 2.54~2.44 (m, 4H), 2.37 (s, 3H), 1.96 (d, J=7.2 Hz, 3H).
29		(R)-4-(1-(5-((4-(7-methylbenzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile	427	CD ₃ OD δ 9.30 (s, 1H), 7.84 (s, 2H), 7.62~7.61 (m, 1H), 7.44 (s, 2H), 7.10~6.93 (m, 3H), 6.13 (m, 1H), 3.66 (d, J=14.8 Hz, 1H), 3.57~3.50 (m, 2H), 3.40 (d, J=14.8 Hz, 1H), 3.12 (m, 2H), 2.57~2.49 (m, 4H), 2.40~2.38 (m, 3H), 1.96 (m, 3H).
30		(R)-4-(1-(5-((4-(6-fluorobenzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile	431	CD ₃ OD δ 9.31 (s, 1H), 7.79 (d, J=8.0 Hz, 2H), 7.62 (s, 1H), 7.45 (d, J=8.4 Hz, 2H), 7.22~7.14 (m, 2H), 6.97~6.92 (m, 1H), 6.14 (q, J=7.2 Hz, 1H), 3.63

		yl)ethyl)benzonit rile		(d, J=14.4 Hz, 1H), 3.54~3.35 (m, 5H), 2.52~2.43 (m, 4H), 1.96 (d, J=7.2 Hz, 3H).
31		(R)-4-(1-(5-((4- (6,7- difluorobenzo[d] oxazol-2- yl)piperazin-1- yl)methyl)-1H- imidazol-1- yl)ethyl)benzonit rile	449	CD ₃ OD δ 9.31 (s, 1H), 7.79 (d, J=8.4 Hz, 2H), 7.61 (s, 1H), 7.45 (d, J=8.4 Hz, 2H), 7.10~6.97 (m, 2H), 6.15 (q, J=7.2 Hz, 1H), 3.63 (d, J=14.4 Hz, 1H), 3.57~3.43 (m, 4H), 3.37 (d, J=14.4 Hz, 1H), 2.56~2.40 (m, 4H), 1.96 (d, J=7.2 Hz, 3H).
32		2-(4-((1-(1- (tetrahydro-2H- pyran-4- yl)ethyl)-1H- imidazol-5- yl)methyl)pipera zin-1- yl)benzo[d]oxaz ole	396	CD ₃ OD δ 9.16 (s, 1H), 7.56 (s, 1H), 7.34 (d, J=8.0 Hz, 1H), 7.29 (d, J=7.6 Hz, 1H), 7.20 (t, J=7.6 Hz, 1H), 7.11~7.07 (m, 1H), 4.57~4.49 (m, 1H), 4.01 (dd, J1=3.6 Hz, J2=11.2 Hz, 1H), 3.92 (dd, J1=3.6 Hz, J2=7.2 Hz, 1H), 3.74~3.71 (m, 6H), 3.44~3.33 (m, 2H), 2.68 (m, 4H), 2.17~2.09 (m, 1H), 1.77 (d, J=12.8 Hz, 1H), 1.56 (d, J=6.8 Hz, 3H), 1.50~1.40 (m, 2H), 1.35 (d, J=12.8 Hz, 1H).

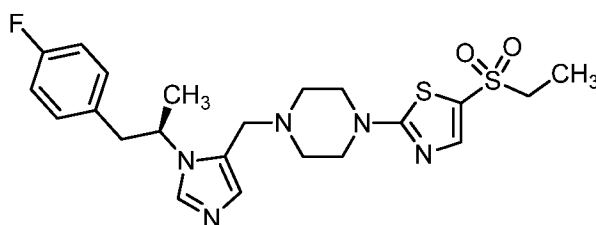
33		2-(4-((1-(2-(pyridin-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole	389	CD ₃ OD δ 8.82 (s, 1H), 8.58 (s, 1H), 8.14~8.12 (m, 1H), 7.60 (d, J=7.2 Hz, 2H), 7.48 (s, 1H), 7.25 (d, J=8.0 Hz, 1H), 7.19 (d, J=8.0 Hz, 1H), 7.10 (t, J=7.6 Hz, 1H), 7.03~6.98 (m, 1H), 4.67 (t, J=7.2 Hz, 2H), 3.77 (s, 2H), 3.66 (s, 4H), 3.52~3.50 (m, 2H), 2.72 (s, 4H).
34		2-(4-((1-(1-(4-(methanesulfonyl)phenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole	466	CD ₃ OD δ 9.25 (s, 1H), 7.88 (d, J=8.4 Hz, 2H), 7.55 (s, 1H), 7.42 (d, J=8.4 Hz, 2H), 7.27 (d, J=8.0 Hz, 1H), 7.21 (d, J=7.6 Hz, 1H), 7.13 (t, J=7.6 Hz, 1H), 7.06~7.02 (m, 1H), 6.06 (q, J=6.8 Hz, 1H), 3.62 (d, J=14.4 Hz, 1H), 3.50~3.47 (m, 2H), 3.46~3.33 (m, 3H), 2.98 (s, 3H), 2.53~2.39 (m, 4H), 1.89 (d, J=6.8 Hz, 3H).
35		6,7-difluoro-2-(4-((1-(1-(tetrahydro-2H-pyran-4-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole	432	δ 9.28 (s, 1H), 7.75 (s, 1H), 7.30~7.29 (m, 2H), 7.17~7.12 (m, 2H), 5.98~5.96 (m, 1H), 4.05~3.69 (m, 2H), 2.94~2.64 (m, 5H),

		yl)methyl)piperazin-1-yl)benzo[d]oxazole		2.01~1.91 (m, 7H).
36		2-(4-((1-(3,3,3-trifluoro-2-methylpropyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole	394	CD ₃ OD δ 9.13 (s, 1H), 7.64 (s, 1H), 7.39 (d, J=8.0 Hz, 1H), 7.33 (d, J=7.2 Hz, 1H), 7.25 (t, J=7.2 Hz, 1H), 7.16 (t, J=7.2 Hz, 1H), 4.73 (dd, J ₁ =2.8 Hz, J ₂ =14.4 Hz, 1H), 4.42 (dd, J ₁ =3.6 Hz, J ₂ =14.4 Hz, 1H), 3.97 (s, 2H), 3.78~3.75 (m, 4H), 3.38~3.32 (m, 1H), 2.80~2.77 (m, 4H), 1.21 (d, J=6.8 Hz, 3H).
37		2-(4-((1-(4-fluorophenethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole	406	CD ₃ OD δ 8.78 (s, 1H), 7.59 (s, 1H), 7.41~7.39 (m, 1H), 7.35~7.33 (m, 1H), 7.27~7.24 (m, 1H), 7.20~7.16 (m, 3H), 7.03 (t, J=8.4 Hz, 2H), 4.58 (t, J=8.4 Hz, 2H), 3.81 (s, 6H), 3.22 (t, J=7.2 Hz, 2H), 2.87 (m, 4H).
38		(R)-4-(1-(5-((4-(6-methoxybenzo[d]thiazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)methyl)-1H-imidazole	459	CD ₃ OD δ 9.32 (s, 1H), 7.78 (d, J=8.0 Hz, 2H), 7.63 (s, 1H), 7.44 (d, J=8.0 Hz, 2H), 7.39 (d, J=7.2 Hz, 1H), 7.33~7.32 (m, 1H), 7.00 (dd, J ₁ =2.4 Hz, J ₂ =4.8

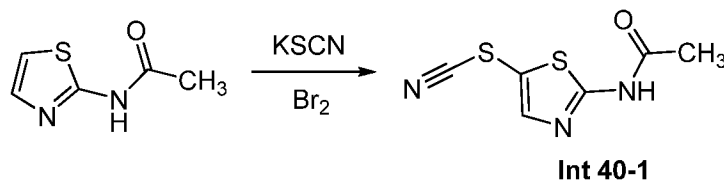
		yl)ethyl)benzonit rile		Hz, 1H), 6.13 (q, J=6.8 Hz, 1H), 3.80 (s, 3H), 3.68 (d, J=14.8 Hz, 1H), 3.56~3.40 (m, 5H), 2.63~2.49 (m, 4H), 1.96 (d, J=6.8 Hz, 3H).
39		(R)-4-(1-(5-((4- (1H- benzo[d]imidazo l-2-yl)piperazin- 1-yl)methyl)-1H- imidazol-1- yl)ethyl)benzonit rile	412	CD ₃ OD δ 9.32 (s, 1H), 7.79 (d, J=8.0 Hz, 2H), 7.63 (s, 1H), 7.46 (d, J=8.0 Hz, 2H), 7.37 (dd, J1=3.2 Hz, J2=6.0 Hz, 2H), 7.29 (dd, J1=3.2 Hz, J2=6.0 Hz, 2H), 6.12 (q, J=7.2 Hz, 1H), 3.67 (d, J=14.4 Hz, 1H), 3.56~3.40 (m, 5H), 2.64~2.50 (m, 4H), 1.97 (d, J=7.2 Hz, 3H).

EXAMPLE 40

(R)-5-(ethylsulfonyl)-2-(4-((1-(1-(4-fluorophenyl)propan-2-yl)-1H-imidazol-5-
yl)methyl)piperazin-1-yl)thiazole (Compound 40)

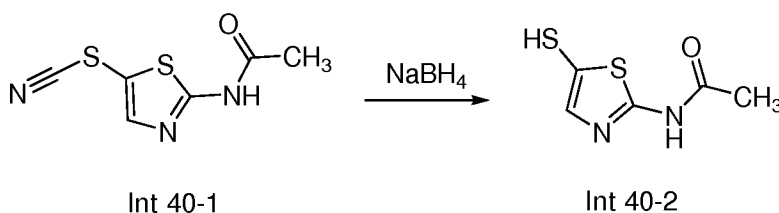


Step A – Preparation of Int 40-1



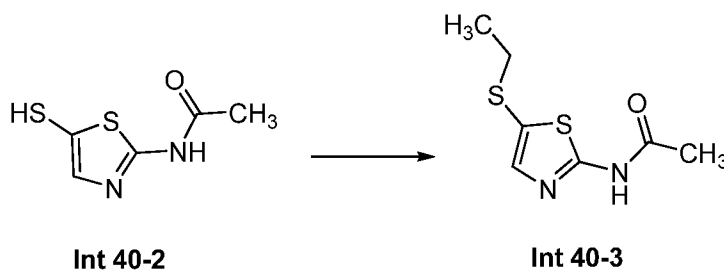
To a stirred solution of compound N-acetyl-2-aminothiazole (10.0 g, 0.07 mol) and KSCN (12.3 g, 0.13 mol) in 100 mL of ethanol was added Br₂ (18 mL, 0.35 mol) at 0°C. The mixture was stirred at room temperature for 16h. The resulting mixture was diluted with ethanol and filtered to afford 5 grams of the crude compound Int 40-1 as yellow solid. MS (ESI) m/z (M+1): 200.

Step B – Preparation of Int 40-2



To a stirred solution of compound Int 40-1 (3.5 g, 0.017 mol) in 40 mL of methanol was added NaBH₄ (0.97 g, 0.025 mol) at 0°C and the mixture was stirred at room temperature for 16h. The result mixture was concentrated to afford 3.0 g of the crude compound Int 40-2 as yellow solid. MS (ESI) m/z (M+1): 175.

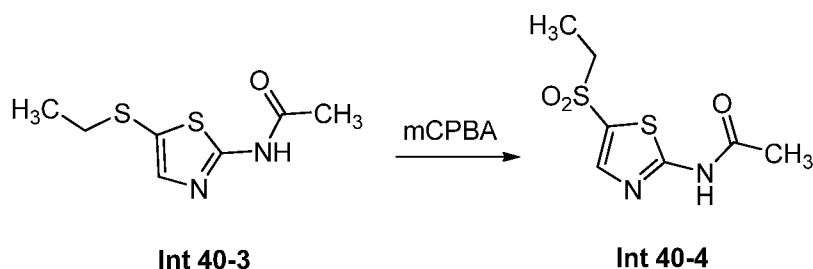
Step C – Preparation of Int 40-3



Compound Int 40-2 (3.0 g, 0.017 mol), iodoethane (2.9 g, 0.018 mol), KF (1.28 g, 0.022 mol), CuI (716 mg, 5.1 mmol), Al₂O₃ (520 mg, 5.1 mmol) and 15 mL of DMF were combined in a 30

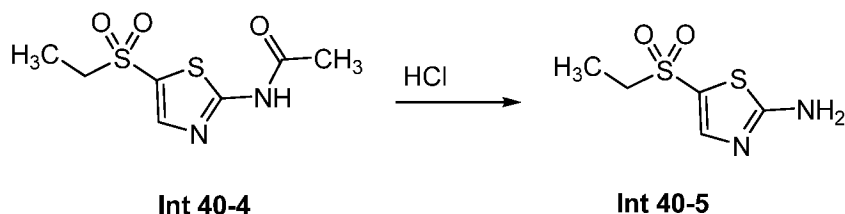
mL three-necked round bottom flask. The mixture was degassed with nitrogen and stirred at 110°C for 16h. The reaction mixture was cooled to room temperature and filtered. The filtrate was concentrated to give crude product which was purified by column chromatography on silica gel with petroleum ether/ethyl acetate (1:1) to afford 2.0 g of compound Int 40-3 as a brown solid. MS (ESI) $m/z(M+1)$: 203.

Step D – Preparation of Int 40-4



To a solution of compound Int 40-3 (1.5 g, 7.4 mmol) in dichloromethane (20mL) was added m-CPBA (3.84 g, 22.3 mmol). The mixture was stirred at room temperature overnight. The mixture was quenched by saturated aqueous $\text{Na}_2\text{S}_2\text{O}_3$ and washed with DCM x3. The combined organic extracts were dried over MgSO_4 , filtered and concentrated to give crude product which was purified by preparative TLC to afford 1.4 g of compound Int 40-4 as a white solid. MS (ESI) $m/z(M+1)$: 235.

Step E – Preparation of Int 40-5

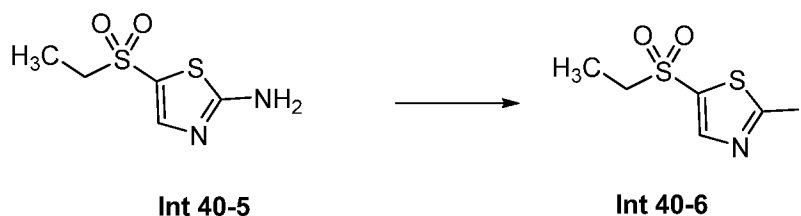


To a stirred solution of compound Int 40-4 (1.4 g, 5.98 mmol) in 6 mL of ethanol was added 6M HCl (2 mL). The mixture was heated to 80°C for 12 h. The reaction was concentrated and the residue was basified with saturated NaHCO_3 and washed with EtOAc. The organic extracts were

dried and concentrated to afford the crude aminothiazole which was used in the next step without further purification. MS (ESI) m/z (M+1): 193.

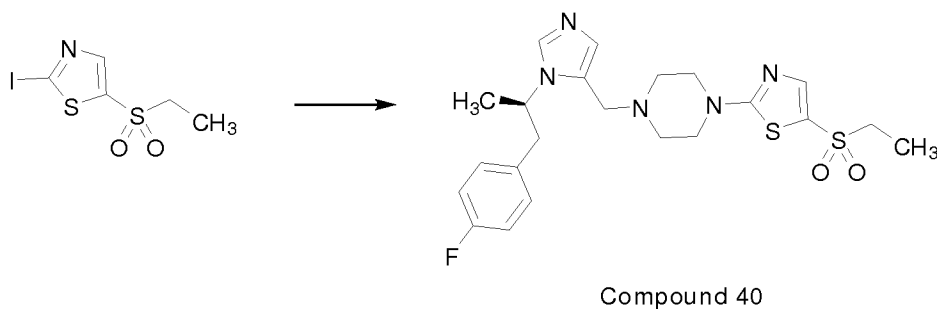
Step F – Preparation of Int 40-6

5



Compound Int 40-5 (560 mg, 2.90 mmol) was dissolved in CH_2I_2 (5 mL). The mixture was heated to 70°C for 2 h then concentrated. The residue was purified by column chromatography on silica gel with petroleum ether/ethyl acetate=1:1 to afford 850 mg of compound Int 40-6 as a yellow solid. MS(ESI) m/z (M+1) = 304. ^1H NMR (CD_3OD) δ 8.04 (s,1H), 3.36~3.35 (m,2H), 1.28 (t, $J=7.2\text{Hz}$, 3H).

15 Step G– Preparation of Compound 40

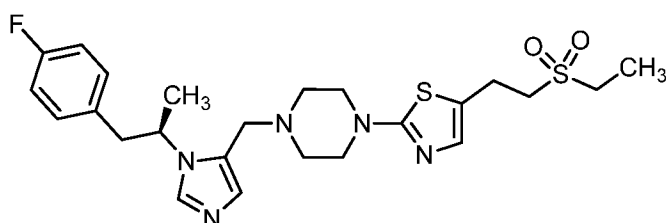


To a stirred solution of compound Int 40-6 (200 mg, 0.66 mmol) in CH_3CN (8 mL) was added K_2CO_3 (1.98 mmol) and 900 mg (9.2 mmol) of the piperazine analog (prepared as described in Example 1 starting from (R)-1-(4-fluorophenyl)propan-2-amine). The mixture was stirred at 105°C for 2 h. The reaction mixture was cooled and added to water (5 mL) and EtOAc (10mL). The aqueous layer was extracted with EtOAc (3×5 mL). The combined organic washings were dried over MgSO_4 and concentrated to give crude product which was purified by HPLC to afford 32 mg of Compound 40. ^1H NMR (CD_3OD) δ 9.21 (s,1H), 7.67 (s, 1H), 7.48 (s, 1H), 7.17~7.14 (m, 2H), 7.05~7.01 (m, 2H), 5.06 (q, $J=6.8\text{Hz}$, 1H), 3.61~3.57 (m, 5H), 3.43 (d,

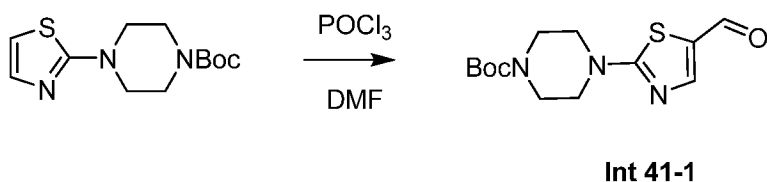
$J=14.4\text{Hz}$, 1H), 3.25~3.14 (m, 4H), 2.65~2.63 (m, 4H), 1.65 (d, $J=6.8\text{Hz}$, 3H), 1.29 (t, $J=7.2\text{Hz}$, 3H). MS(ESI) $m/z(M+1)$: 478.

EXAMPLE 41

5 (R)-5-(2-(ethylsulfonyl)ethyl)-2-(4-((1-(1-(4-fluorophenyl)propan-2-yl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)thiazole (Compound 41)



10 Step A – Preparation of Int 41-1

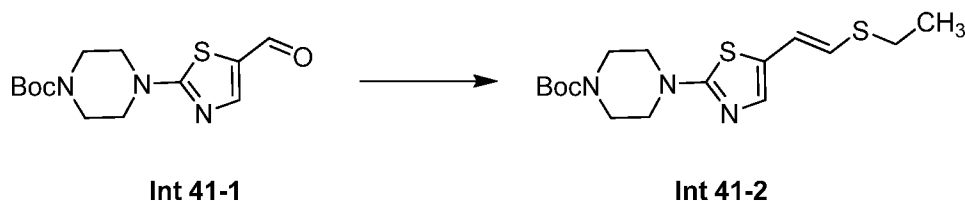


To a solution of tert-butyl 4-(thiazol-2-yl)piperazine-1-carboxylate (2 g, 0.74 mmol) in DMF (20 mL) was added POCl_3 (17.08 g, 11.2 mmol). The mixture was stirred at 50°C for 3h. The resulting mixture was poured into cold water and filtered. The filter cake was washed with water and collected to afford 2 g of white solid. MS-ESI (m/z): 242 ($M-55$)⁺. ^1H NMR (CDCl_3) δ : 9.68 (s, 1H), 7.84 (s, 1H), 3.61 (br, 4H), 3.56 (br, 4H).

15

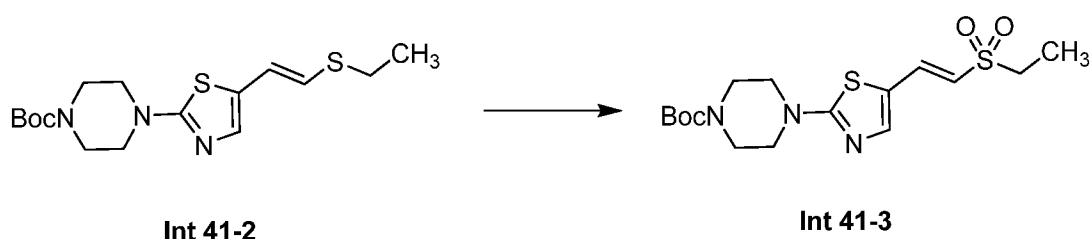
Step B – Preparation of Int 41-2

20



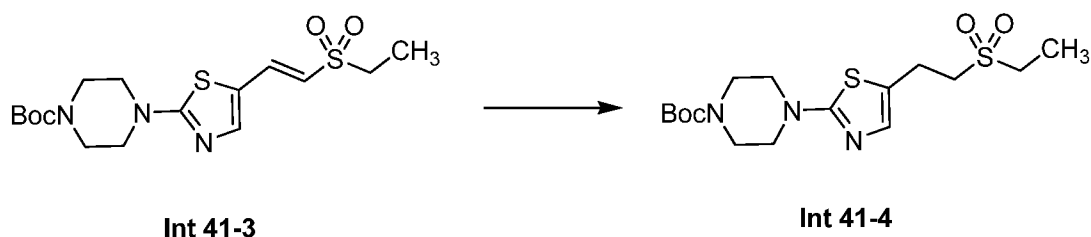
To a solution of compound diethyl ((ethylthio)methyl)phosphonate (71.4 mg, 0.34 mmol) in THF (2 mL) was added NaH (9.7 mg, 0.4 mmol). The mixture was stirred at room temperature for 1 h then compound 1 was added. The resulting mixture was stirred for 16 h then quenched with water and extracted with DCM (3x). The combined organic washings were dried over
 5 MgSO₄ and concentrated. The crude residue was purified by preparative TLC to give 58 mg of white solid. MS-ESI (m/z): 300 (M-55)⁺. ¹H NMR (CDCl₃) δ: 6.88 (s, 2H), 6.43 (d, J=15.2 Hz, 1H), 6.07 (d, J=15.2 Hz, 1H), 3.47 (br, 4H), 3.39 (br, 4H), 2.69 (q, J=7.6, 2H), 1.41 (s, 9H), 1.26 (t, J=7.6, 3H).

10 Step C – Preparation of Int 41-3



To a solution of compound Int 41-2 (0.5 g, 1.4 mmol) in CH₂Cl₂ (10 mL) was added mCPBA
 15 (0.49 g, 2.8 mmol). The mixture was stirred at room temperature for 40 min. The reaction mixture was quenched with saturated Na₂SO₃ and extracted with CH₂Cl₂ (3×10 mL). The combined organic extracts were dried over MgSO₄ and concentrated to afford 0.4 g of yellow solid. MS-ESI (m/z): 332 (M-55)⁺.

20 Step D – Preparation of Int 41-4

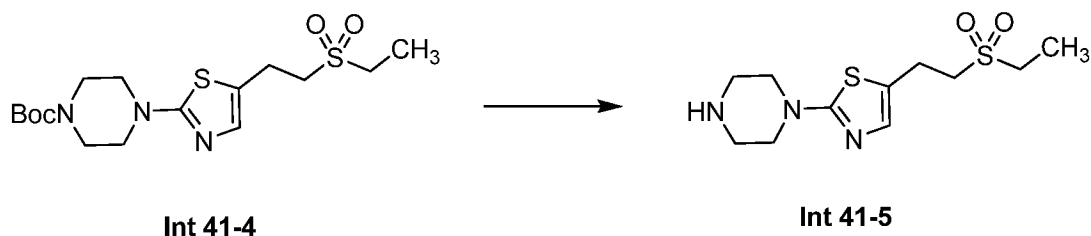


To a solution of Int 41-3 (0.4 g, 1.03 mmol) in methanol (1 mL) was added Pd/C (0.05 g). The
 25 mixture was charged with H₂ (50 psi) and the mixture was stirred at 40°C for 16 h. The mixture

was then filtered through Celite and the filtrate was concentrated to dryness. The crude material was used in next step directly. MS-ESI (m/z): 334 (M-55)⁺.

Step E – Preparation of Int 41-5

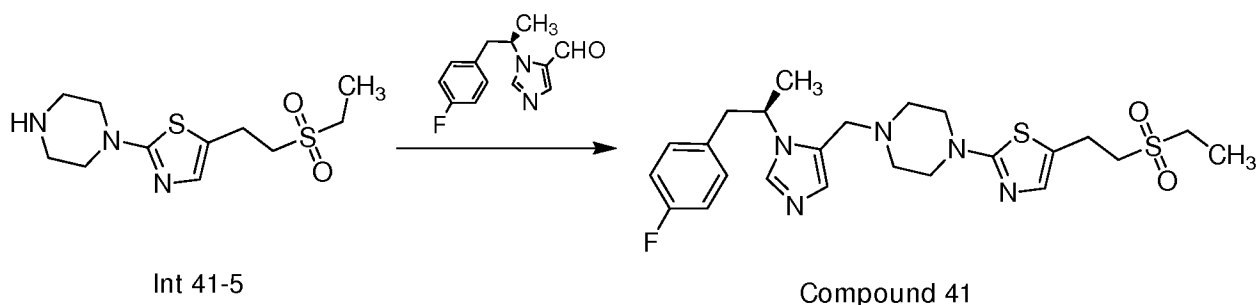
5



Compound Int 41-4 (1 g, 2.57 mmol) was dissolved in HCl / EtOAc (10 mL) and the mixture was stirred at room temperature for 30 min. The mixture was concentrated to dryness and used in next step directly. MS-ESI (m/z): 290 (M+1)⁺.

10

Step F– Preparation of Compound 41



15

To a solution of compound Int 41-5 (100 mg, 0.44 mmol) in CH₂Cl₂ (2 mL) was added Et₃N (0.1 mL) followed by 128 mg (0.44 mmol) of the aldehyde analog (prepared as described in Example 1 starting from (R)-1-(4-fluorophenyl)propan-2-amine). The mixture was stirred for 1h then NaBH(OAc)₃ (282 mg, 1.33 mmol) was added. The resulting mixture was stirred at room temperature for 16 h. The reaction mixture was quenched with water and extracted with CH₂Cl₂ (3x). The combined organic layer was dried over MgSO₄ and concentrated. The crude was purified by HPLC to give 30 mg of white solid. MS-ESI (m/z): 506 (M+1)⁺. ¹H NMR (CD₃OD) δ 9.17 (s, 1H), 7.45 (s, 1H), 7.18-7.11 (m, 3H), 7.00 (t, J=8.8 Hz, 2H), 5.10-4.98 (m,

25

1H), 3.70-3.50 (m, 5H), 3.43-3.33 (m, 3H), 3.28-3.09 (m, 5H), 2.52-2.50 (br, 4H), 1.62 (d, J=6.8 Hz, 3H), 1.40-1.28 (m, 4H).

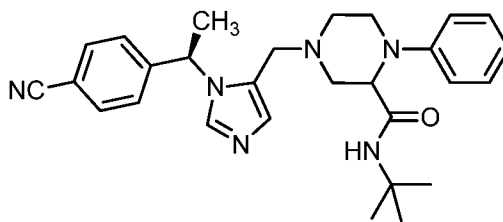
The following compounds 42-43 were prepared using a protocol similar to that described in

- 5 Example 41 and an appropriately substituted imidazole carboxaldehyde (prepared as illustrated in Example 1).

Cmpd	Structure	IUPAC name	M+1	¹ H NMR
42		(R)-2-(4-((1-(1-(4-chlorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)-5-(2-(ethylsulfonyl)ethyl)thiazole	508	CD ₃ OD δ 9.25 (s, 1H), 7.60 (s, 1H), 7.42 (d, J=8.4 Hz, 2H), 7.27 (d, J=8.4 Hz, 2H), 7.18 (s, 1H), 6.03 (s, 1H), 3.65 (d, J=14.4 Hz, 1H), 3.55-3.38 (m, 7H), 3.19 (t, J=7.6 Hz, 2H), 3.10 (q, J=7.2, 2H), 2.68-2.49 (m, 4H), 1.93 (d, J=6.8 Hz, 3H), 1.33 (t, J=7.6 Hz, 3H).
43		(R)-2-(4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)-5-(2-(ethylsulfonyl)ethyl)thiazole	492	CD ₃ OD δ 9.23 (s, 1H), 7.60 (s, 1H), 7.38-7.30 (m, 2H), 7.19 (s, 1H), 7.13 (t, J=6.8 Hz, 2H), 6.03 (q, J=6.8 Hz, 1H), 4.26-4.00 (m, 1H), 3.68 (d, J=14.4 Hz, 1H), 3.55-3.38 (m, 7H), 3.19 (t, J=7.6 Hz, 2H), 3.10 (q, J=7.2, 2H), 2.68-2.49 (m, 4H), 1.93 (d, J=6.8 Hz, 3H), 1.33 (t, J=7.6 Hz, 3H).

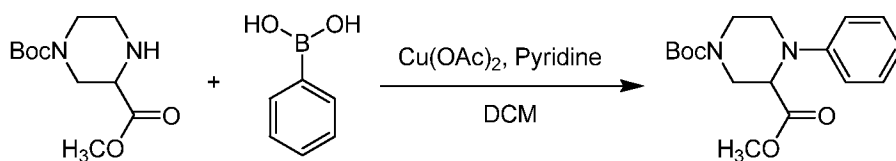
EXAMPLE 44

N-(tert-butyl)-4-((1-((R)-1-(4-cyanophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-phenylpiperazine-2-carboxamide (Compound 44)



5

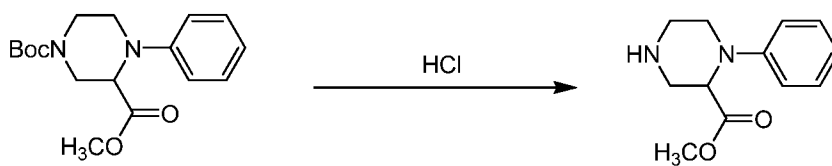
Step A – Preparation of Int 44-1



Int 44-1

- 10 To a solution of 1-tert-butyl 3-methyl piperazine-1,3-dicarboxylate (2.44 g, 10 mmol) in DCM (50 mL) was added phenylboronic acid (2.35 g, 20 mmol), Cu(OAc)₂ (1.82 g, 10 mmol) and pyridine (1.58 g, 20 mmol) in turns with stirring. The reaction mixture was stirred at ambient temperature for 24 hrs under an oxygen atmosphere. The reaction mixture was filtered and filtrate was concentrated. The residue was purified by column chromatography on silica gel (petroleum ether : EtOAc= 3:1) to afford compound Int 44-1 (2.74 g). MS-ESI (m/z): 321 (M+1)⁺ R_f: 0.3 (PE : EtOAc= 3 : 1).
- 15

Step B – Preparation of Int 44-2



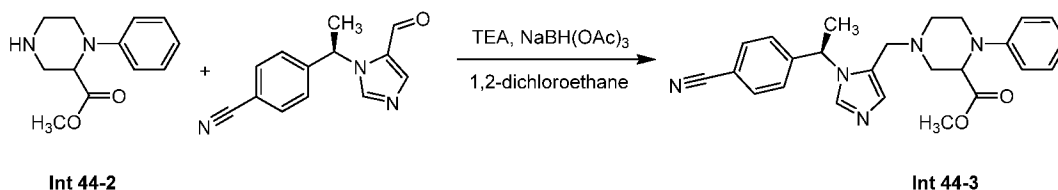
Int 44-1

Int 44-2

20

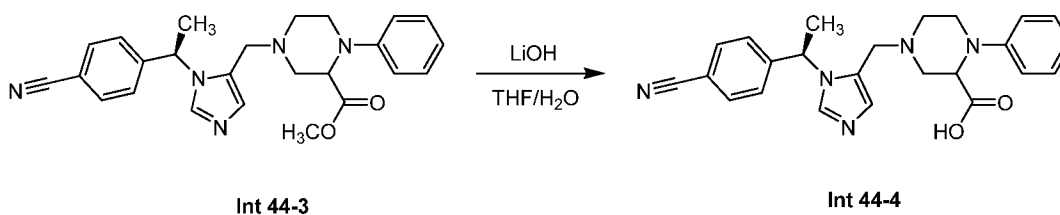
HCl gas was bubbled into an ice cold solution of compound Int 44-1 (2.73 g, 8.5 mmol) in 20 mL of EtOAc for 10 minutes. The reaction mixture was stirred to room temperature over an hour then concentrated to afford Int 44-2 (1.38 g). MS-ESI (m/z): 221 (M+1)⁺.

Step C – Preparation of Int 44-3



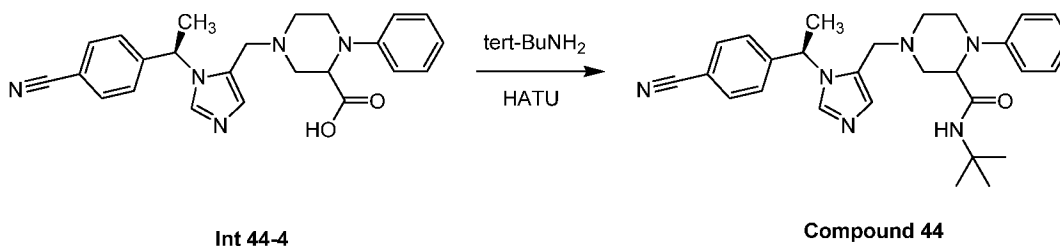
To a solution of compound Int 44-2 (1.38 g, 5.1 mmol) in 1,2-dichloroethane (20 mL) was added the imidazole carboxaldehyde (1.14 g, 5.1 mmol) and TEA (0.71 mL, 10.2 mmol) with stirring under N₂. The reaction mixture was stirred at ambient temperature for 2 h before NaBH(OAc)₃ was added. The reaction mixture was stirred another 16 h before being quenched with saturated NH₄Cl. The mixture was extracted with EtOAc and the organic washings were dried, filtered and concentrated. The residue was purified by column chromatography on silica gel (petroleum ether : EtOAc= 1:1) to afford compound Int 44-3 (1.77 g). MS-ESI (m/z): 430 (M+1)⁺ R_f: 0.3 (PE : EtOAc= 1 : 1).

Step D – Preparation of Int 44-4



To a solution of compound Int 44-3 (478.4 mg, 1.1 mmol) in THF (6 mL) and water (3 mL) was added LiOH·H₂O (59.4 mg, 1.45 mmol) with stirring. The reaction mixture was stirred at 25°C for 15 h. The reaction mixture was extracted with EtOAc and then the aqueous layer was adjusted pH to 5 by conc. HCl. The result solution was extracted with EtOAc, the organic layers were combined and dried, filtered and concentrated to afford compound Int 44-4 (370 mg). MS-ESI (m/z): 416 (M+1)⁺.

Step E – Preparation of Int 44-5



To a solution of compound Int 44-4 (99.1 mg, 0.24 mmol) in DCM (1 mL) was added DIPEA (93.1 mg, 0.72 mmol) and HATU (98.8 mg, 0.26 mmol) in turns with stirring. After being

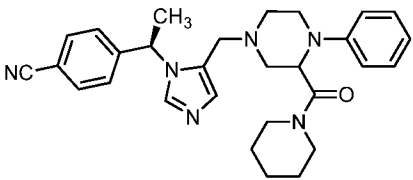
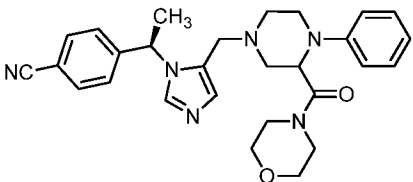
5 stirred at 25°C for 30 min, the reaction mixture was treated with tert-butylamine (0.26 mmol), and stirring continued for another 10 h. The reaction mixture was concentrated and purified by HPLC to afford Compound 44. ¹H NMR (CD₃OD) δ: 9.33 (d, *J*=46.8 Hz, 1H), 7.74 (q, *J*=8.4 Hz, 2H), 7.59 (t, *J*₁=31.2 Hz, *J*₂=23.2 Hz, 2H), 7.44 (d, *J*=8.4 Hz, 1H), 7.43~7.26 (m, 2H), 7.05 (d, *J*=8.0 Hz, 1H), 6.98~6.94 (m, 2H), 6.52 (t, *J*₁=1.2 Hz, *J*₂=6.8 Hz, 1H), 3.84 (q, *J*=14.4 Hz,

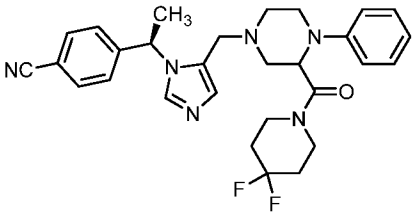
10 1H), 3.68 (t, *J*₁=26.8 Hz, *J*₂=14.4 Hz, 1H), 3.49~3.42 (m, 2H), 3.29~3.09 (m, 2H), 2.90 (t, *J*₁=11.6 Hz, *J*₂=9.6 Hz, 1H), 2.69 (d, *J*=12 Hz, 1H), 2.34 (t, *J*₁=50.8 Hz, *J*₂=1.6 Hz, 1H), 1.96 (q, *J*=7.2 Hz, 3H), 1.31 (d, *J*=9.6 Hz, 9H). MS-ESI (*m/z*): 471 (M+1)⁺.

The following compounds 45-47 were prepared as described in Example 44 starting from

15 carboxylic acid intermediate Int 44-4 and an amine coupling partner.

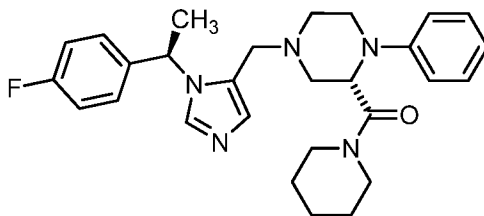
Cmpd	Structure	IUPAC name	M+1	¹ H NMR
45a		4-(((1R)-1-(5-((4-phenyl-3-(piperidine-1-carbonyl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile: diastereomer A	483	CD ₃ OD δ: 9.35 (s, 1H), 7.76 (t, <i>J</i> ₁ =12.8 Hz, <i>J</i> ₂ =4.8 Hz, 3H), 7.44 (d, <i>J</i> =8.4 Hz, 2H), 7.27 (q, <i>J</i> =7.2 Hz, 2H), 7.00 (d, <i>J</i> =4.0 Hz, 2H), 6.91 (t, <i>J</i> ₁ =14.8 Hz, <i>J</i> ₂ =7.2 Hz, 1H), 6.55 (q, <i>J</i> =6.8 Hz, 1H), 4.12 (q, <i>J</i> =2.8 Hz, 1H), 3.72 (q, <i>J</i> =10 Hz, 4H), 3.68~3.52 (m, 4H), 3.30~3.24 (m, 1H),

				3.06~2.93 (m, 2H), 2.80~2.73 (m, 1H), 1.98 (d, J=7.2 Hz, 3H), 1.68 (t, J1=10 Hz, J2=5.2 Hz, 5H), 1.62 (s, 1H).
45b		4-((1R)-1-(5-((4-phenyl-3-(piperidine-1-carbonyl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile: diastereomer B	483	CD ₃ OD δ: 9.30 (s, 1H), 7.74 (d, J=8.0 Hz, 2H), 7.61 (s, 1H), 7.54 (d, J=8.4 Hz, 2H), 7.24 (d, J1=15.2 Hz, J2=7.6 Hz, 2H), 6.921 (s, 3H), 6.70 (d, J=7.2 Hz, 1H), 3.95 (d, J=14 Hz, 1H), 3.73 (d, J=10.4 Hz, 1H), 3.61 (s, 3H), 3.51 (d, J=11.2 Hz, 2H), 3.36 (d, J=14.4 Hz, 1H), 3.26 (t, J1=17.6 Hz, J2=1.2 Hz, 1H), 2.76~2.65 (m, 2H), 2.38 (t, J1=22.4 Hz, J2=10.8 Hz, 1H), 2.03 (d, J=11.6 Hz, 1H), 1.93 (d, J=7.2 Hz, 3H), 1.70 (d, J=4.8 Hz, 2H), 1.62 (s, 2H), 1.55 (d, J=3.2 Hz, 2H).
46		4-((1R)-1-(5-((3-(morpholine-4-carbonyl)-4-phenylpiperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile	485	δ: 9.33 (d, J=0.8 Hz, 1H), 7.75 (d, J=8.4 Hz, 2H), 7.64 (s, 1H), 7.54 (d, J=8.4 Hz, 2H), 7.30 (t, J1=16 Hz, J2=7.6 Hz, 2H), 6.99 (t, J1=8.8 Hz, J2=6.0 Hz, 3H), 6.64 (q, J=6.8 Hz, 1H), 4.01 (d,

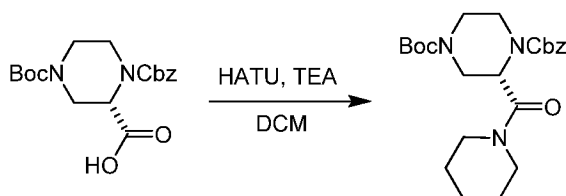
				J=14 Hz, 1H), 3.87~3.83 (m, 1H), 3.68~3.28 (m, 11H), 2.82 (q, J=10.4 Hz, 1H), 2.72 (d, J=12 Hz, 1H), 2.52~2.45 (m, 1H), 2.10 (q, J=9.2 Hz, 1H), 1.93 (d, J=7.2 Hz, 3H).
47		4-((1R)-1-(5-((3-(4,4-difluoropiperidin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile	519	δ : 9.32 (s, 1H), 7.73 (d, J=8.4 Hz, 2H), 7.61 (s, 1H), 7.55 (d, J=8.4 Hz, 2H), 7.26 (q, J=7.2 Hz, 2H), 6.94 (d, J=8.0 Hz, 3H), 6.70 (q, J=7.2 Hz, 1H), 3.98 (d, J=14 Hz, 1H), 3.84~3.72 (m, 4H), 3.66~3.48 (m, 4H), 3.37 (d, J=14 Hz, 1H), 3.29~3.22 (m, 1H), 2.73 (t, J1=22 Hz, J2=11.6 Hz, 1H), 2.62 (d, J=11.6 Hz, 1H), 2.38 (t, J1=22.4 Hz, J2=11.2 Hz, 1H), 2.00 (q, J=41.6 Hz, 3H), 1.93 (d, J=7.2 Hz, 3H).

EXAMPLE 48

((S)-4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-phenylpiperazin-2-yl)(piperidin-1-yl)methanone (Compound 48)



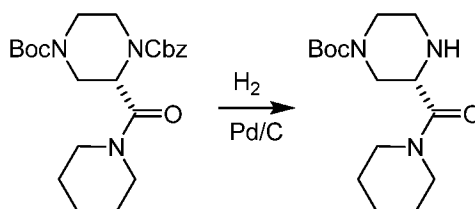
Step A – Preparation of Int 48-1



Int 48-1

To a solution of piperazine carboxylic acid (10 g, 27 mmol) in DCM (50 mL) was added TEA (2.39 mL, 54 mmol) and HATU (11.4 g, 30 mmol) with stirring. The reaction mixture was stirred at room temperature for 30 mins then treated with piperidine (2.57 g, 30 mmol). The reaction solution was stirred for 48 hrs then concentrated. The residue was purified by column chromatography on silica gel eluted with petroleum ether / EtOAc (3 : 1) to afford compound Int 48-1 as yellow oil (10.7g). MS-ESI (m/z): 432 (M+1)⁺ R_f: 0.6 (PE : EtOAc= 1 : 1) ¹H NMR (CDCl₃) δ: 7.30~7.24 (m, 5H), 5.25 (s, 1H), 5.14 (d, J=12.3 Hz, 1H), 5.06~4.98 (m, 1H), 4.18~3.80 (m, 5H), 3.41 (s, 2H), 3.21 (d, J=13 Hz, 3H), 1.61 (s, 2H), 1.52 (t, J₁=16.6 Hz, J₂=14.7 Hz, 3H), 1.39 (s, 10H).

Step B – Preparation of Int 48-2



Int 48-1

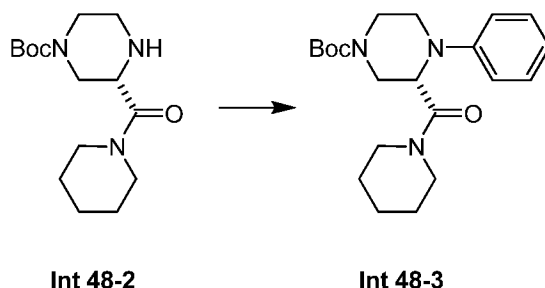
Int 48-2

A mixture of compound Int 48-1 (10.75 g, 25 mmol) and Pd/C (1.0 g) in MeOH (25 mL) was stirred under 50 Psi of H₂ at room temperature for 10 hrs. The mixture was filtered through

Celite and the filter cake was washed with MeOH. The combined organic layers were concentrated to afford compound Int 48-2 as yellow oil (6.97 g). MS-ESI (m/z): 298 (M+1)⁺.

Step C – Preparation of Int 48-3

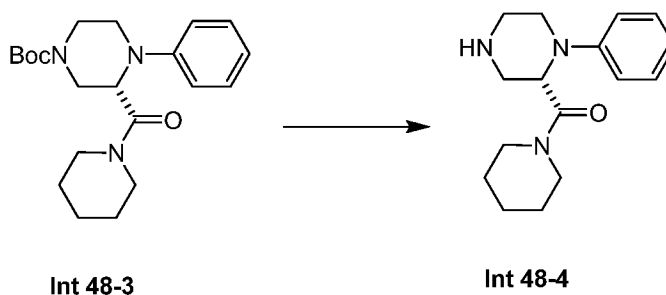
5



To a solution of compound Int 48-2 (6.97 g, 23 mmol) in DCM (70 mL) was added phenylboronic acid (5.72 g, 46 mmol), Cu(OAc)₂ (4.17 g, 23 mmol) and pyridine (3.64 g, 46 mmol) in turns with stirring. The reaction mixture was stirred at room temperature for 16 hrs under an atmosphere of oxygen. The reaction mixture was filtered and the filter cake was washed with DCM. The combined organic layers were concentrated and the residue was purified by column chromatography on silica gel (Petroleum ether : EtOAc = 10 : 1) to afford compound Int 48-3 as yellow oil (6.08 g). MS-ESI (m/z): 374 (M+1)⁺ R_f: 0.5 (PE : EtOAc= 3 : 1) ¹H NMR (CDCl₃) δ: 7.24~7.16 (m, 2H), 7.08 (t, J₁=14.8 Hz, J₂=7.5 Hz, 1H), 6.99 (d, J=8.6 Hz, 2H), 5.17 (d, J=12.2 Hz, 1H), 4.12 (q, J=7.2 Hz, 1H), 4.02~3.92 (m, 1H), 3.82 (d, J=5.2 Hz, 2H), 3.45 (s, 4H), 3.25 (d, J=8.3 Hz, 2H), 1.58 (t, J₁=6.2 Hz, J₂=1.3 Hz, 3H), 1.51 (t, J₁=19.2 Hz, J₂=12.2 Hz, 2H), 1.43 (d, J=9.8 Hz, 10H).

Step D – Preparation of Int 48-4

20

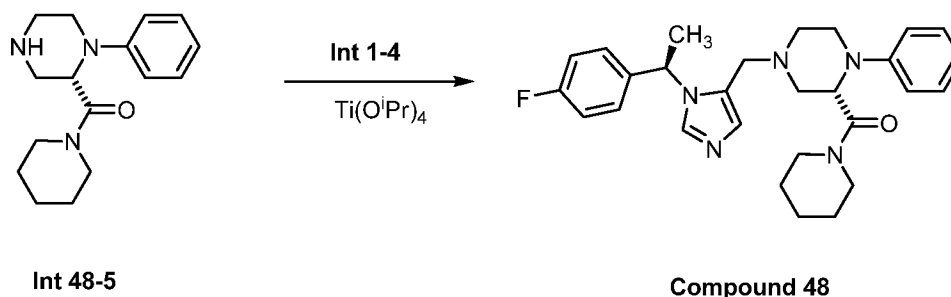


A solution of compound Int 48-3 (6.08 g, 16 mmol) in EtOAc (30 mL) saturated with HCl (g) was stirred at room temperature for 15 mins. The reaction mixture was concentrated to afford

compound Int 48-4 as brown solid (5 g). MS-ESI (m/z): 274 (M+1)⁺ R_f: 0.01 (PE : EtOAc= 3 : 1).

Step E – Preparation of Compound 48

5

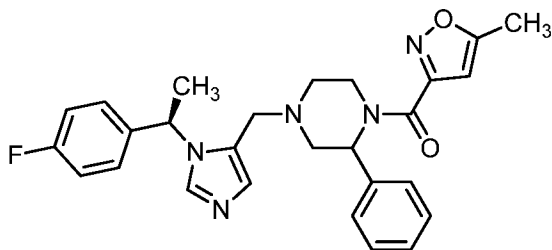


To a solution of compound Int 48-5 (0.5 mmol) in anhydrous THF (3 mL) was added Int 1-4 (97.1 mg, 0.5 mmol), TEA (0.14 mL, 1.0 mmol) and Ti(*i*-PrO)₄ (284.2 mg, 1.0 mmol) with stirring under N₂. The reaction mixture was stirred at 60°C for 2 h. The reaction mixture was cooled to room temperature before NaBH(OAc)₃ (317.9 mg, 1.5 mmol) was added. The reaction mixture was stirred at ambient temperature for another 20 mins under N₂ before being quenched with water. The mixture was filtered and the filter cake was washed with EtOAc. The combined organic layers were dried over Na₂SO₄, filtered and concentrated. The residue was purified by HPLC to afford compound 48 as a white solid. ¹H NMR (CD₃OD) δ: 9.25 (d, *J*=8.0 Hz, 1H), 7.75 (d, *J*=6.8 Hz, 1H), 7.36 (t, *J*₁=22 Hz, *J*₂=13.2 Hz, 4H), 7.20 (d, *J*=8.0 Hz, 2H), 7.11 (s, 2H), 7.00 (s, 1H), 6.07 (s, 1H), 3.87 (q, *J*=13.2 Hz, 2H), 3.70 (t, *J*₁=27.6 Hz, *J*₂=13.2 Hz, 2H), 3.49 (q, *J*=48.4 Hz, 4H), 3.22 (t, *J*₁=48 Hz, *J*₂=12 Hz, 2H), 3.04 (t, *J*₁=35.2 Hz, *J*₂=12 Hz, 2H), 2.80 (d, *J*=9.6 Hz, 1H), 1.97 (s, 3H), 1.60 (s, 2H), 1.37 (s, 4H). MS-ESI (m/z): 476 (M+1)⁺.

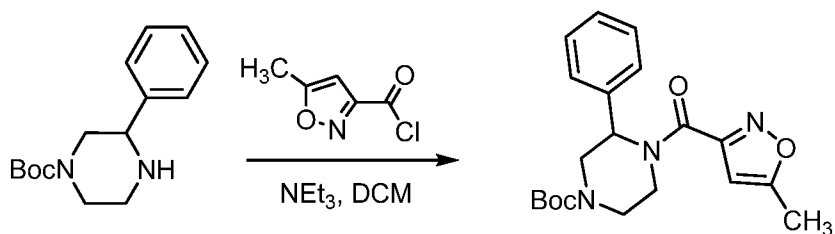
EXAMPLE 49

(4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(5-methylisoxazol-3-yl)methanone (Compound 49)

25



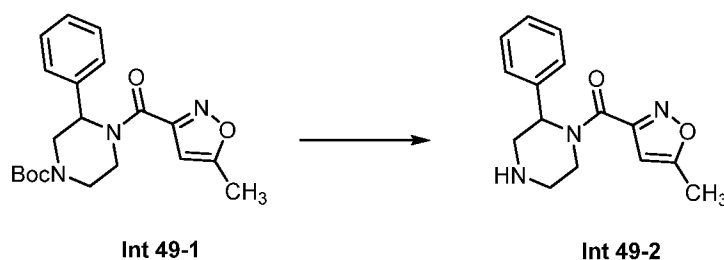
Step A – Preparation of Int 49-1



Int 49-1

To a solution of tert-butyl 3-phenylpiperazine-1-carboxylate (300 mg, 1.14 mmol) and NEt₃ (230 mg, 2.28 mmol) in CH₂Cl₂ (5 mL) was added 5-methylisoxazole-3-carbonyl chloride (182 mg, 1.26 mmol). The reaction mixture was stirred 0°C for 10 min. Water was added and the mixture was extracted with 2x CH₂Cl₂. The organic layers were dried over Na₂SO₄ and concentrated. The residue was purified by prep-TLC to afford 350 mg as yellow solid. ¹H NMR (CD₃OD) δ 7.29~7.21 (m, 5H), 5.74 (m, 1H), 4.59~4.56 (m, 1H), 4.10~4.02 (m, 1H), 3.89~3.83 (m, 1H), 3.38~3.29 (m, 2H), 3.03~2.91 (m, 2H), 2.40~2.32 (m, 3H), 1.32 (s, 9H). MS (ESI) m/z(M+1): 372.

Step B – Preparation of Int 49-2

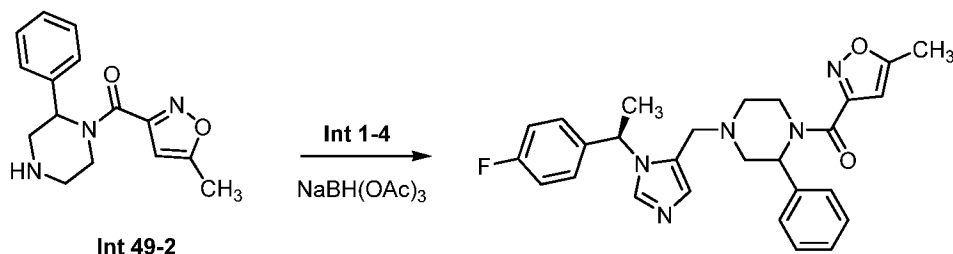


To a solution of compound Int 49-1 (350 mg, 0.94 mmol) in EtOAc (3 mL) was added HCl/EtOAc (10 mL). The mixture was stirred at ambient temperature for 30 min. The resulting

white precipitate was filtered and dried to give 250 mg of the HCl salt of Int 49-2 as white solid. ^1H NMR (CD_3OD) δ 9.39 (t, $J=8.0$ Hz, 2H), 7.31~7.27 (m, 3H), 6.38 (s, 1H), 6.04 (s, 1H), 4.63 (m, 1H), 4.14~4.10 (m, 1H), 3.56~3.51 (m, 1H), 2.39 (s, 3H), 1.91 (s, 1H), 1.89 (m, 2H). MS (ESI) m/z ($M+1$) = 272.

5

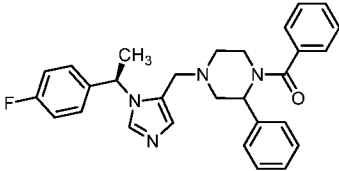
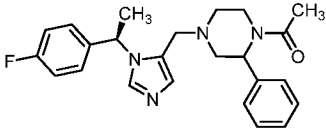
Step B – Preparation of Compound 49

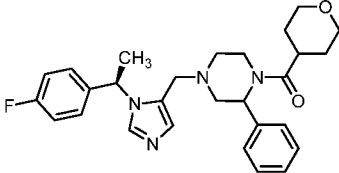
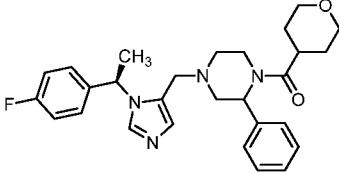
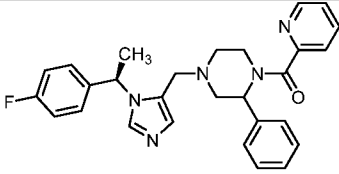


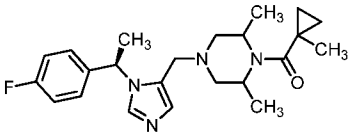
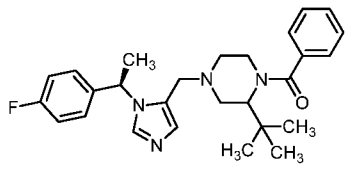
- 10 A mixture compound of Int 49-2 (250 mg, 0.94 mmol), Int 1-4 (205 mg, 0.94 mmol) in CH_2Cl_2 (4 mL) was stirred at room temperature for 3 h. $\text{NaBH}(\text{OAc})_3$ (402 mg, 1.90 mmol) was added and the mixture was stirred for 16 h. Water (2 mL) was added into the reaction solution which was then extracted with CH_2Cl_2 (3x). The organic layers was dried over Na_2SO_4 , concentrated and purified by prep-HPLC to afford Compound 49 as a white solid. ^1H NMR (CD_3OD) δ
- 15 9.08~9.06 (s, 1H), 7.54~7.50 (s, 1H), 7.37~7.18 (m, 5H), 7.05~6.97 (m, 4H), 6.41~6.27 (m, 1H), 5.86~5.53 (m, 2H), 4.55~4.52 (m, 0.5H), 4.13~4.10 (m, 0.5H), 3.63~3.40 (m, 3H), 3.26~3.11 (m, 1H), 2.73~2.63 (m, 2H), 2.56~2.53 (m, 3H), 2.47~2.17 (m, 1H), 1.66~1.56 (m, 3H). MS (ESI) m/z ($M+1$) = 474.

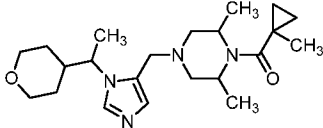
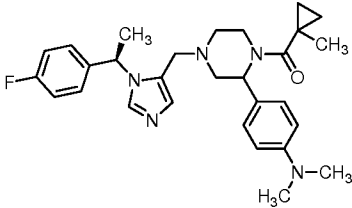
- 20 The following compounds 50-57 were prepared as described in Example 49.

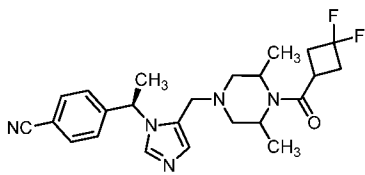
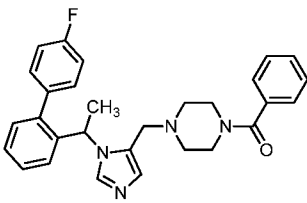
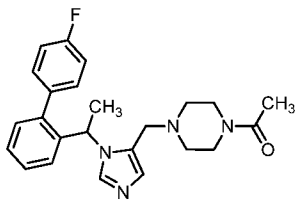
Cmpd	Structure	IUPAC name	M+1	^1H NMR
50a		(4-(((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(phenyl)metha	476	CD_3OD : δ 9.14 (s, 1H), 7.52(q, $J=7.6$ Hz, 3H), 7.43~7.33 (m, 7H), 7.21 (t, $J=6.8$ Hz, 3H), 7.04 (d, $J=8.0$ Hz, 2H), 5.64 (s, 1H), 3.63 (d, $J=14.4$ Hz, 1H), 3.52 (s, 1H),

		none		3.24 (t, J=21.2 Hz, 1H), 3.13 (s, 1H), 2.52 (t, J=9.2 Hz, 2H), 2.20 (t, J=11.2 Hz, 1H), 2.33 (s, 3H).
50b		(4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(phenyl)methanone	476	CD ₃ OD: δ 9.14 (s, 1H), 7.63~7.53 (m, 3H), 7.36~7.21 (m, 9H), 7.06 (q, J=7.6 Hz, 2H), 5.78 (d, J=5.6 Hz, 1H), 3.63 (d, J=14.8 Hz, 2H), 3.50~3.20 (m, 1H), 2.65 (dd, J ₁ =12.0 Hz, J ₂ =4.0 Hz, 2H), 2.15 (t, J=10.8 Hz, 1H), 1.66~1.57 (m, 3H).
51		1-(4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)ethanone	414	CD ₃ OD: δ 9.13 (d, J=13.6 Hz, 1H), 7.58 (d, J=8.0 Hz, 3H), 7.32~7.06 (m, 7H), 5.70~5.45 (m, 2H), 4.44~4.38 (m, 1H), 3.80 (d, J=12.4 Hz, 1H), 3.60 (d, J=14.4 Hz, 1H), 3.48 (d, J=9.6 Hz, 1H), 3.29~3.20 (m, 1H), 2.88 (s, 1H), 2.57 (t, J=11.6 Hz, 1H), 2.39 (d, J=10.4 Hz, 1H), 2.22~1.95 (m, 4H), 1.63 (d, J=28.0 Hz, 3H).

52a		(4-(((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(tetrahydro-2H-pyran-4-yl)methanone	477	CD ₃ OD: δ 9.09~9.03 (m, 1H), 7.54 (s, 1H), 7.31 (s, 2H), 7.19 (s, 1H), 7.13 (m, 2H), 7.00~6.98 (m, 4H), 5.74~5.63 (m, 1H), 5.57~5.36 (m, 1H), 4.47~4.44 (m, 0.5H), 3.96~3.85 (m, 2.5H), 3.58~3.50 (m, 4H), 3.23 (m, 1H), 3.11~2.97 (m, 1H), 2.83~2.78 (m, 0.5H), 2.68~2.65 (m, 1H), 2.52~2.50 (m, 1H), 2.40~2.38 (m, 1H), 2.21~2.15 (m, 1H), 1.87~1.58 (m, 7H), 1.38~1.35 (m, 0.5H).
52b		(4-(((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(tetrahydro-2H-pyran-4-yl)methanone	477	CD ₃ OD: δ 9.06 (s, 1H), 7.49 (s, 1H), 7.36~7.29 (m, 5H), 7.04~6.90 (m, 4H), 5.75 (m, 1.5H), 5.42 (m, 0.5H), 4.43 (m, 0.5H), 3.95~3.82 (m, 2.5H), 3.55~3.46 (m, 5H), 3.06 (m, 1H), 2.84~2.59 (m, 2.5H), 2.12~2.11 (m, 1H), 1.83~1.56 (m, 7H), 1.28~1.27 (m, 0.5H).
53		(4-(((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(pyridin-4-yl)methanone	470	CD ₃ OD: δ 9.07~9.04 (m, 1H), 8.60 (m, 1H), 7.96~7.87 (m, 1H),

		5-yl)methyl)-2-phenylpiperazin-1-yl)(pyridin-2-yl)methanone		7.66~7.21 (m, 8H), 7.05~6.97 (m, 4H), 5.90~5.62 (m, 2H), 3.63~3.26 (m, 4H), 2.79~2.59 (m, 2H), 2.30~2.22 (m, 1H), 1.65~1.55 (m, 3H).
54		(4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2,6-dimethylpiperazin-1-yl)(1-methylcyclopropyl)methanone	399	CD ₃ OD: δ 9.26 (s, 1H), 7.57 (s, 1H), 7.32~7.28 (m, 2H), 7.18 (t, J=8.4 Hz, 2H), 6.17 (q, J=7.2 Hz, 1H), 4.56 (m, 2H), 3.42 (s, 2H), 2.76 (d, J=10.8 Hz, 1H), 2.65 (d, J=11.6 Hz, 1H), 2.23~2.21 (m, 2H), 1.97 (d, J=7.2 Hz, 3H), 1.39~1.28 (m, 9H), 0.90 (s, 2H), 0.60 (s, 2H).
55		(2-(tert-butyl)-4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)(phenyl)methanone	449	CD ₃ OD: δ 9.22~9.19 (m, 1H), 7.59~7.53 (m, 1H), 7.45 (m, 3H), 7.38~7.30 (m, 3H), 7.26~7.23 (m, 1H), 7.18~7.11 (m, 2H), 6.06~5.97 (m, 1H), 4.58~4.53 (m, 1H), 3.63~3.51 (m, 2.5H), 3.42~3.38 (m, 0.5H), 3.32 (s, 1H), 3.24 (m, 0.5H), 3.12~3.09 (m, 0.5H), 2.76~2.73 (m, 0.5H), 2.60~2.57 (m,

				0.5H), 2.30~2.22 (m, 0.5H), 2.18~2.13 (m, 0.5H), 2.09~2.01 (m, 0.5H), 1.93~1.81 (m, 3.5H), 1.13 (m, 3.5H), 1.02~0.79 (m, 6H).
56		(2,6-dimethyl-4-((1-(1-(tetrahydro-2H-pyran-4-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)(1-methylcyclopropyl)methanone	389	CD ₃ OD: δ 9.17 (s, 1H), 7.55 (s, 1H), 4.63~4.55 (m, 3H), 3.99 (dd, J ₁ =3.6 Hz, J ₂ =11.6 Hz, 1H), 3.88 (dd, J ₁ =3.2 Hz, J ₂ =11.6 Hz, 1H), 3.78 (d, J=14.8 Hz, 1H), 3.62 (d, J=14.4 Hz, 1H), 3.42~3.28 (m, 2H), 2.94 (d, J=11.2 Hz, 1H), 2.78 (d, J=11.2 Hz, 1H), 2.36~2.34 (m, 1H), 2.24~2.22 (m, 1H), 2.14~2.06 (m, 1H), 1.76~1.73 (m, 1H), 1.60 (d, J=7.2 Hz, 3H), 1.44~1.18 (m, 12H), 0.90 (s, 2H), 0.60 (s, 2H).
57		(2-(4-(dimethylamino)phenyl)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)methanone	490	CD ₃ OD: δ 9.15 (s, 1H), 7.64~7.50 (m, 5H), 7.22~7.12 (m, 4H), 5.76 (m, 2H), 4.38 (d, J=13.2 Hz, 1H), 3.70~3.62 (m, 2H), 3.53 (d, J=14.4 Hz, 1H), 3.25~3.16 (m, 7H), 3.81 (d, J=10.8 Hz, 1H),

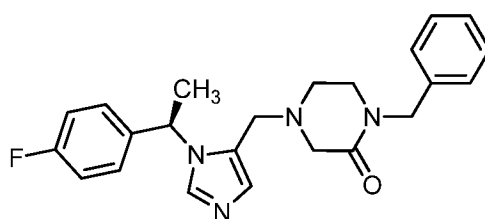
		zin-1-yl)(1-methylcyclopropyl)methanone		2.67 (d, J=10.8 Hz, 1H), 2.21~2.16 (m, 1H), 1.79~1.69 (m, 3H), 1.35 (s, 3H), 0.99~0.95 (m, 2H), 0.69 (m, 2H).
58		4-((1R)-1-(5-((4-(3,3-difluorocyclobutanecarbonyl)-3,5-dimethylpiperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile	442	CD ₃ OD: δ 9.32 (s, 1H), 7.78 (d, J=8.4 Hz, 2H), 7.61 (s, 1H), 7.41 (d, J=8.0 Hz, 2H), 6.23 (q, J=7.2 Hz, 1H), 4.49~4.48 (m, 1H), 4.00~3.96 (m, 1H), 3.39 (dd, J ₁ =14.8 Hz, J ₂ =32.8 Hz, 1H), 3.23~3.20 (m, 1H), 2.88~2.84 (m, 6H), 2.18 (m, 1H), 2.06 (m, 1H), 1.99 (d, J=7.2 Hz, 3H), 1.30~1.23 (m, 6H).
59		(4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)(phenyl)methanone	469	CD ₃ OD: δ 8.92 (s, 1H), 7.35-7.48 (m, 9H), 7.18-7.27 (m, 5H), 5.99 (q, J=6.8Hz, 1H), 3.61 (s, 2H), 3.12 (d, J=14.4Hz, 1H), 2.95 (d, J=14.4Hz, 1H), 2.11-2.35 (m, 4H), 1.96 (d, J=6.8Hz, 3H).
60		1-(4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-	407	CD ₃ OD: δ 8.92 (s, 1H), 7.41-7.49 (m, 4H), 7.19-7.27 (m, 5H), 5.98-6.01 (m, 1H), 3.38-4.41 (m, 4H), 3.10 (d, J=14.4Hz,

		yl)methyl)piperazin-2-one		1H), 2.93 (d, J=14.4Hz, 1H), 2.09-2.26 (m, 4H) 1.95 (d, J=6.8Hz, 3H).
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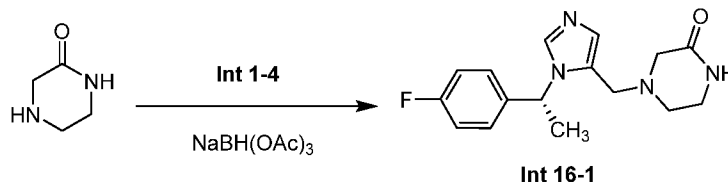
EXAMPLE 61

(R)-1-benzyl-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one

(Compound 61)



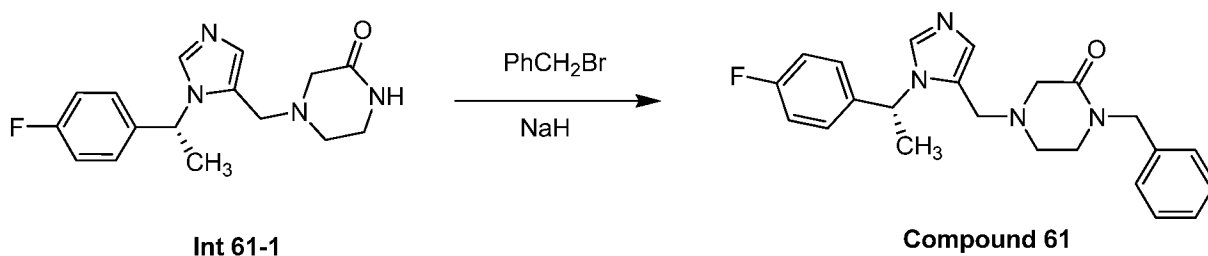
Step A – Preparation of Int 61-1



To a solution of piperazinone (0.917 g, 9.17 mmol) and Int 1-4 (2 g, 9.17 mmol) in DCM (20 mL) was added NaBH(OAc)₃ (1.94 mg, 9.17 mmol). The mixture was stirred at room

temperature overnight, then water (10 mL) was added to quench the reaction. The reaction mixture was extracted with CH₂Cl₂ (3 x 20 mL) and the combined organic extracts were washed with brine (15 mL), dried over Na₂SO₄ and concentrated to give 2g of the product Int 16-1 which was used directly for the next step. MS (ESI): *m/z* (M+H)⁺ 303.

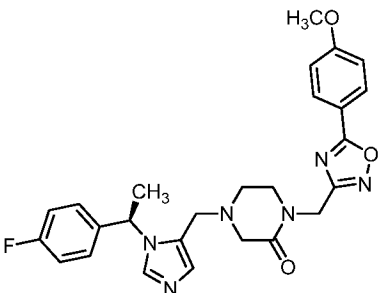
Step B – Preparation of Compound 61



To a solution of Int 61-1 (5 g, 25 mmol) in DMF (4 mL) was added NaH (26 mg, 0.66 mmol, 60 % in oil) at 0°C. The reaction was stirred for 3 h before 3.0 mL (25 mmol) of benzyl bromide was added. After stirring for 16h the reaction mixture was diluted with water (10 mL) then
 5 extracted 3 times with EtOAc. The combined organic extracts were washed with brine (10 mL), dried over Na₂SO₄ and concentrated. The residue was purified by HPLC to give 195 mg of Compound 61. ¹H NMR (CD₃OD) : δ 9.22 (s, 1H), 7.55 (s, 1H), 7.23-7.35 (m, 7H), 7.06 (t, *J*= 17.2 Hz, 2H), 5.93-5.98 (m, 1H), 4.49-4.59 (m, 2H), 3.68 (d, *J*= 14.4 Hz, 1H), 3.48 (d, *J*= 14.4 Hz, 1H), 3.03-3.21 (m, 4H), 2.56-2.69 (m, 2H), 1.90 (d, *J*= 7.2 Hz, 3H). MS (ESI): *m/z*
 10 (M+H)⁺ 393.2.

The following compounds 62-64 were prepared as described in Example 61 from Int 61-1 and an appropriately substituted halide.

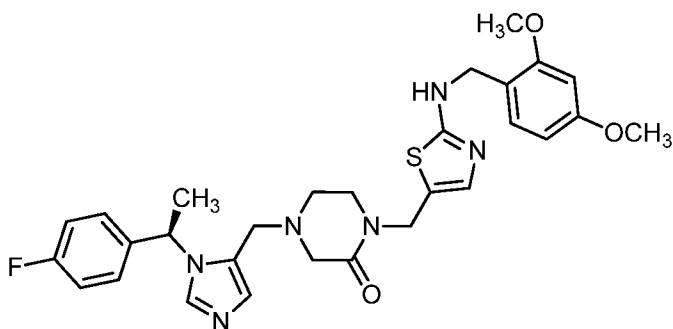
Cmpd	Structure	IUPAC name	M+1	¹ H NMR
62		(R)-1-(2-((1H-1,2,4-triazol-1-yl)methyl)benzyl)-4-((1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one	474	CD ₃ OD : δ 9.23 (s, 1H), 8.50 (s, 1H), 7.98 (s, 1H), 7.58 (s, 1H), 7.21-7.35 (m, 6H), 7.06-7.10 (m, 2H), 5.94-5.99 (m, 1H), 5.49 (s, 1H), 4.67-4.76 (m, 2H), 3.64 (d, <i>J</i> = 14.4 Hz, 1H), 3.45 (d, <i>J</i> = 14.4 Hz, 1H), 2.97-3.16 (m, 4H), 2.53-2.66 (m, 2H), 1.91 (d, <i>J</i> = 7.2 Hz, 3H).
63		(R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-(imidazo[1,2-a]pyridin-2-yl)methyl)piperazin-2-one	433	CD ₃ OD δ 9.26 (s, 1H), 8.74 (d, <i>J</i> = 6.8 Hz, 1H), 8.15 (s, 1H), 7.87-7.98 (m, 2H), 7.60 (s, 1H), 7.47 (t, <i>J</i> = 14 Hz, 2H), 7.05-7.26 (m, 2H), 7.03

		ylmethyl)piperazin-2-one		(t, J = 17.2 Hz, 2H), 5.93-5.95 (s, 1H), 4.71-4.80 (m, 2H), 3.68 (d, J = 14.4 Hz, 1H), 3.46 (d, J = 14.4 Hz, 1H), 3.30-3.48 (m, 1H), 3.02-3.22 (m, 3H), 2.60-2.74 (m, 2H), 1.90 (d, J = 7.2 Hz, 3H).
64		(R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((5-(4-methoxyphenyl)-1,2,4-oxadiazol-3-yl)methyl)piperazin-2-one	491	CD ₃ OD: δ 9.20 (s, 1H), 8.03 (d, J = 8.8 Hz, 2H), 7.59 (s, 1H), 7.31-7.34 (m, 2H), 7.06-7.22 (m, 4H), 5.98-6.03 (m, 1H), 4.71 (s, 1H), 3.81 (s, 3H), 3.04-3.68 (m, 6H), 2.68-2.80 (m, 2H), 1.92 (d, J = 7.2 Hz, 3H).

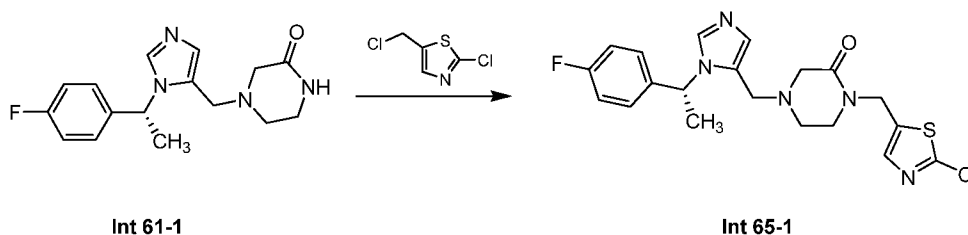
EXAMPLE 65

(R)-1-((2-((2,4-dimethoxybenzyl)amino)thiazol-5-yl)methyl)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one (Compound 65)

5

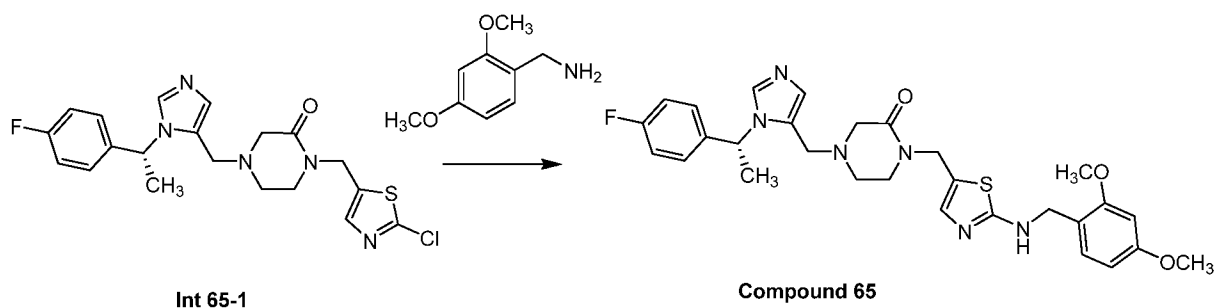


Step A – Preparation of Int 65-1



- 5 To a solution of Int 61-1 (200 mg, 0.66 mmol) in DMF (4 mL) was added NaH (100 mg, 2.5 mmol, 60 % in oil) at 0°C and the reaction mixture was stirred at this temperature for 3 h. 2-chloro-5-(chloromethyl)thiazole (110 mg, 0.66 mmol) was added to the reaction and stirring was allowed to continue overnight. The reaction mixture was diluted with water (10 mL) and extracted with EtOAc (3 times). The organic washings were washed with brine (10 mL), dried
- 10 over Na₂SO₄ and concentrated. The residue was purified by column chromatography (Petroleum Ether : EtOAc = 10:1) to give Int 65-1 (210 mg) which was used into next step without further purification. ¹H NMR (CD₃OD) : δ 9.41 (s, 1H), 7.79 (s, 1H), 7.70 (s, 1H), 7.29-7.33 (m, 2H), 7.11-7.16 (m, 1H), 5.94-6.01 (m, 1H), 5.64 (s, 2H), 3.60 (d, *J*=16.0Hz, 1H), 3.42 (d, *J*=16.0Hz, 1H), 3.03-3.21 (m, 2H), 3.00 (d, *J*=16.0Hz, 1H), 2.90 (d, *J*=16.0Hz, 1H), 2.41-2.70 (m, 2H), 1.91
- 15 (d, *J*=7.2Hz, 3H). MS (ESI): *m/z* (M+H)⁺ 433.2, 435.2.

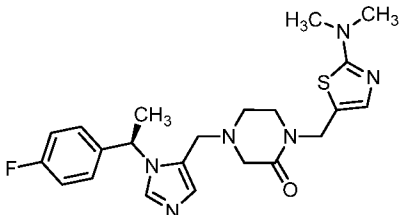
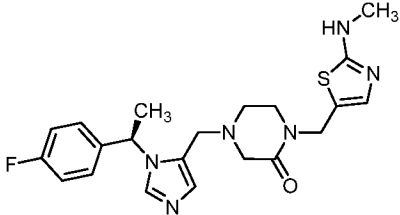
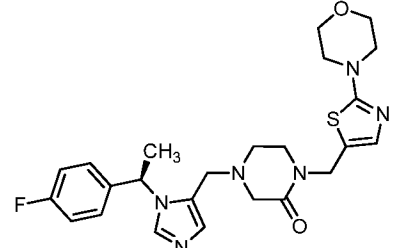
Step B – Preparation of Compound 65



- 20 To a solution of compound Int 65-1 (200 mg, 0.46 mmol) in DMF (5 mL) was added K₂CO₃ (126 mg, 0.92 mmol) and 2,4-dimethoxybenzylamine piperazine (77 mg, 0.46 mmol). The reaction was stirred at 120°C overnight before being cooled and filtered. The filtrate was concentrated and the residue was purified by HPLC to give Compound 65. ¹H NMR (CD₃OD) :
- 25 δ 9.27 (s, 1H), 7.59 (s, 1H), 7.36 (m, 2H), 7.20-7.27 (m, 4H), 7.00 (t, *J*=17.6Hz, 2H), 6.48-6.57

(m, 2H), 5.88-5.93 (m, 1H), 4.35-4.48 (m, 4H), 3.81 (s, 3H), 3.77 (s, 3H), 3.45-3.70 (m, 1H), 3.42-3.44 (m, 1H), 2.97-3.23 (m, 3H), 2.59-2.65 (m, 2H), 1.90 (d, $J=7.2\text{Hz}$, 3H). MS (ESI): m/z (M+H)⁺ 465.2.

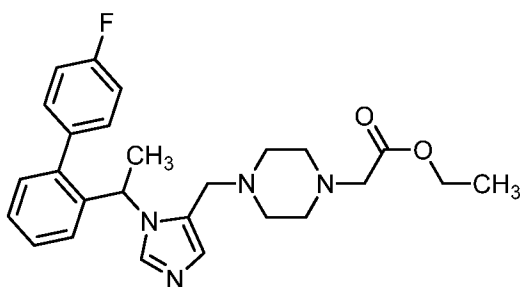
5 The following compounds 66-69 were prepared as described in Example 65.

Cmpd	Structure	IUPAC name	M+1	¹ H NMR
66		(R)-1-((2-(dimethylamino)thiazol-5-yl)methyl)-4-((1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one	443	CD ₃ OD : δ 9.27 (s, 1H), 7.59 (s, 1H), 7.36 (m, 2H), 7.23-7.26 (m, 2H), 7.05 (t, $J=17.6\text{Hz}$, 2H), 5.89-5.95 (m, 1H), 3.70 (d, $J=14.4\text{Hz}$, 1H), 3.45 (d, $J=14.4\text{Hz}$, 1H), 2.94-3.26 (m, 9H), 2.59-2.65 (m, 2H), 1.90 (d, $J=7.2\text{Hz}$, 3H).
67		(R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((2-(methylamino)thiazol-5-yl)methyl)piperazin-2-one	429	CD ₃ OD : δ 9.26 (s, 1H), 7.59 (s, 1H), 7.23-7.29 (m, 3H), 7.02-7.07 (m, 2H), 5.91-5.93 (m, 1H), 4.42-4.44 (m, 2H), 3.68 (d, $J=16.0\text{Hz}$, 1H), 3.43 (d, $J=16.0\text{Hz}$, 1H), 2.94-3.22 (m, 7H), 2.57-2.67 (m, 2H), 1.91 (d, $J=7.2\text{Hz}$, 3H).
68		(R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((2-morpholinothiazol-5-yl)methyl)piperazin-2-one	485	CD ₃ OD : δ 9.25 (s, 1H), 7.59 (s, 1H), 7.24-7.27 (m, 3H), 7.03-7.07 (m, 2H), 5.90-5.93 (m, 1H), 4.43-4.51 (m, 2H), 3.43-3.81 (m, 9H), 2.94-3.23

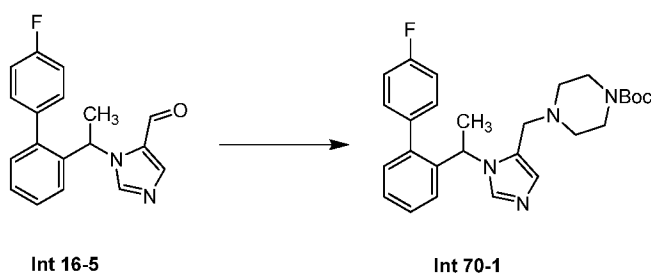
Cmpd	Structure	IUPAC name	M+1	¹ H NMR
		ol-5-yl)methyl)piperazin-2-one		(m, 4H), 2.59-2.66 (m, 2H), 1.91 (d, <i>J</i> =7.2Hz, 3H).
69		(R)-4-(((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((2-(4-methylpiperazin-1-yl)thiazol-5-yl)methyl)piperazin-2-one	498	CD ₃ OD : δ 9.25 (s, 1H), 7.58 (s, 1H), 7.25-7.28 (m, 2H), 7.19 (s, 1H), 7.04 (t, <i>J</i> =17.6Hz, 2H), 5.90-5.95 (m, 1H), 4.45-4.55 (m, 2H), 2.99-3.79 (m, 14H), 3.09 (s, 3H), 2.58-2.66 (m, 2H), 1.89 (d, <i>J</i> =7.2Hz, 3H).

EXAMPLE 70

ethyl 2-(4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)acetate (Compound 70)

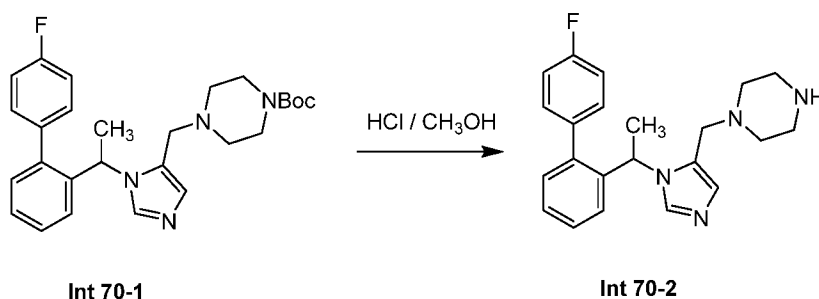


Step A – Preparation of Int 70-1



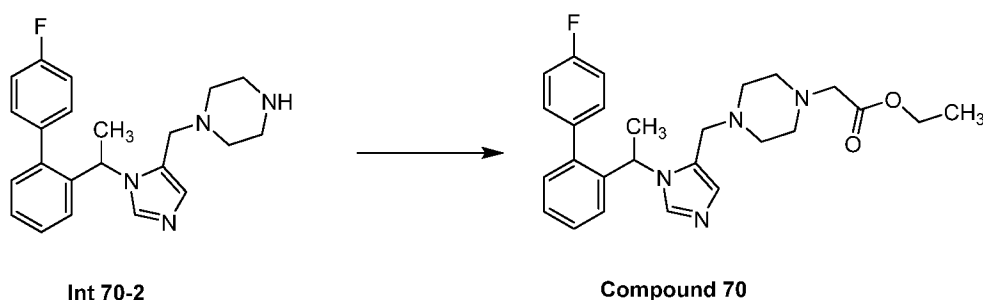
To a solution of Int 16-5 (1.0 g, 3.40 mmol) in DMF (20 mL) was added Et₃N (343 mg, 3.40 mmol), N-Boc-piperazine (200 mg, 0.68 mmol) and Ti(EtO)₄ (2.3 g, 10.20 mmol). The reaction mixture was heated to 80°C overnight then cooled. NaBH(AcO)₃ (1.4 g, 6.80 mmol) was added at room temperature and the mixture was stirred for another 6 h. The mixture was poured into H₂O (20 mL) and extracted with EtOAc (20 mL × 3). The combined organic extracts were washed with aqueous saturated sodium bicarbonate (10 mL) and brine (10 mL), dried over sodium sulfate and concentrated. The crude mixture purified by column chromatography with Petroleum Ether:EtOAc=5:1 to give Int 70-1. ¹H NMR (CDCl₃) δ 7.56 (s, 1H), 7.31-7.33 (m, 2H), 7.06-7.17 (m, 5H), 7.82 (s, 1H), 5.62 (q, *J*=7.2Hz, 1H), 3.19 (s, 4H), 2.98 (d, *J*=14.0Hz, 1H), 2.85 (d, *J*=14.0Hz, 1H), 2.15-2.19 (m, 2H) 2.03-2.09 (m, 2H), 1.69 (d, *J*=7.2Hz, 3H), 1.42 (s, 9H). MS (APCI): *M/Z* (*M*+1) 465.2.

Step B – Preparation of Int 70-2



The mixture of Int 70-1 (1.0 g, 2.16 mmol) in 4M HCl/MeOH (4N, 20 mL) was stirred at 0°C for 3 h. The mixture was concentrated to give Int 70-2 (900 mg) which was used into the next step without further purification. MS (APCI): *M/Z* (*M*+1) 365.2.

Step C – Preparation of Compound 70



To the solution of Int 70-2 (100 mg, 0.23 mmol) in DMF (3 mL) was added Et₃N (93 mg, 0.92 mmol) and ethyl bromoacetate (0.46 mmol). The mixture was heated at 80°C overnight. The crude mixture was and purified by HPLC to afford Compound 70 (54 mg). ¹H NMR (CD₃OD):

5 δ 8.91 (s, 1H), 7.42-7.48 (m, 4H), 7.19-7.27 (m, 5H), 5.91 (q, *J*=7.0Hz, 1H), 4.28 (q, *J*=7.2Hz, 2H), 4.08 (s, 2H), 3.14 (d, *J*=14.4Hz, 1H), 2.99 (d, *J*=14.4Hz, 1H), 2.46-2.57 (m, 4H), 1.96 (d, *J*=6.8Hz, 3H), 1.29 (t, *J*=7.2Hz, 3H). MS (ESI): *m/z* (M+H)⁺ 451.2.

The following compounds 71-72 were prepared as described in Example 70.

10

Cmpd	Structure	IUPAC name	M+1	¹ H NMR
71		2-(4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)pipera-zin-1-yl)ethanol	409	CD ₃ OD : δ 8.91 (s, 1H), 7.42-7.47 (m, 4H), 7.19-7.27 (m, 5H), 5.92 (q, <i>J</i> =7.0Hz, 1H), 3.64 (t, <i>J</i> =4.8Hz, 2H), 3.47-3.49 (m, 2H), 3.20-3.23 (m, 2H), 3.14 (d, <i>J</i> =14.4Hz, 1H), 2.99 (d, <i>J</i> =14.4Hz, 1H), 2.50-2.72 (m, 2H), 2.26-2.47 (m, 2H), 1.96 (d, <i>J</i> =7.2Hz, 3H).
72		1-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)-4-(2-methoxyethyl)pi perazine	423	CD ₃ OD : δ 8.91 (s, 1H), 7.42-7.48 (m, 4H), 7.19-7.28 (m, 5H), 5.92 (q, <i>J</i> =7.0Hz, 1H), 3.67 (t, <i>J</i> =4.8Hz, 2H), 3.46 (s, 2H), 3.37 (s, 3H), 3.14 (d, <i>J</i> =14.4Hz, 1H), 2.98 (d, <i>J</i> =14.4Hz, 1H), 2.90-2.96 (m, 2H), 2.59-2.70 (m, 2H), 2.24-2.34 (m, 2H), 1.96 (d, <i>J</i> =7.2Hz,

				3H).
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EXAMPLE 73

Determination of IC₅₀ in a Cocktail Assay for CYPs 1A2, 2C9, 2C19, 2D6 and 3A4:

5

This assay was performed in a standard 96-well plate design. IC₅₀ values were calculated from the percent inhibition observed for each test compound at 6 concentrations (for example, 0.0032, 0.016, 0.08, 0.4, 2 and 10 μ M). The incubation substrate mix contains 10 μ M phenacetin (1A2), 5 μ M diclofenac (2C9), 30 μ M mephenytoin (2C19), 5 μ M dextromethorphan (2D6) and 2 μ M

10

midazolam (3A4), 0.1 mg/mL protein human liver microsomes (BD Gentest), 1 mM NADPH, 3.3 mM MgCl₂ and 100 mM potassium phosphate buffer (pH 7.4). The production of the metabolite of each probe substrate was determined after incubation for 10 min at 37°C.

Quantitation of the metabolite peak area ratio against an internal standard (tolbutamide) was determined by LC/MS/MS analysis following acetonitrile treatment of the incubations.

15

Probe Substrate	Reaction (isoform)	Metabolite Detected
Phenacetin	O-deethylation (CYP1A2)	Acetaminophen
Diclofenac	4'-hydroxylation (CYP2C9)	4'-Hydroxydiclofenac
Mephenytoin	4'-hydroxylation (CYP2C19)	4'-Hydroxymephenytoin
Dextromethorphan	O-demethylation (CYP2D6)	Dextrorphan
Midazolam	1'-hydroxylation (CYP3A4)	1'-Hydroxymidazolam

Samples were analyzed in the MRM mode with a SCIEX API-4000 mass spectrometer (Applied Biosystems, Foster City, CA), with a Shimadzu LC-20 AD pump (Shimadzu corporation, Kyoto, JP) and a CTC PAL autosampler (Agilent Technologies, Switzerland). A Phenomenex, Luna, 5 μ m, 100A, 2.00 x 30 mm HPLC column was used for the separation. The mobile phases were:

20

(A) 0.1% formic acid in water and (B) 0.1% formic acid in acetonitrile. The binary gradient was as follows.

AutoSampler: CTC PAL

Loop Volume 1 (user entered) 100 μ L

Loop Volume 2 (user entered) 100 μ L

Actual Injection Volume 10.0 μ L

Binary Gradient

Total Flow: 700 μ L/min

Time (min)	A (%)	B (%)
0.01	98	2
0.40	30	70
0.80	2	98
1.00	System Controller	Stop

5 The mass spectrum parameters were as follows:

MS Parameters:

CUR Curtain gas (psi):	20
GS1 Ion source gas1(psi):	50
GS2 Ion source gas2(psi):	60
IS IonSpray voltage (V):	5500
TEM Temperature ($^{\circ}$ C):	600
ihe Interface heater (on/off):	ON
CAD Collision Activated Dissociation (psi):	10
EP Entrance Potential (V):	10
CXP Collision Cell Exit Potential (V)	12

The LC/MS/MS parameters for the analytes were as follows.

10

LC/MS/MS Analysis

Compound	Ion Transition		DP	CE	RT
	Q1 Mass (m/z)	Q3 Mass (m/z)	Declustering Potential (V)	Collission Energy (V)	Retention Time (min)
Acetaminophen	152.2	110	40	23	0.36
4'-Hydroxydiclofenac	312	231	32	29	0.72
4'-Hydroxymephenytoin	235.3	150.3	45	25	0.49

Dextrophan	258.2	157.2	40	55	0.42
1'-hydroxymidazolam	342.2	203.2	40	30	0.53
IS	271.1	155.3	69	25	0.71

The peak area ratio of the analyte to the internal standard was used to quantify the metabolite.

The values of peak area ratios in the presence of test compound were compared to those of maximum or minimum controls and were expressed as % inhibition by interpolating between the maximum and minimum peak area ratios. Incubations with no inhibitor were defined as the maxima.

The following equation was used to calculate the % inhibition:

$$[1 - [(X - \text{Low control})/(\text{High control} - \text{Low control})]] \times 100$$

For the IC₅₀ calculation, SigmaPlot was used to plot the mean % inhibition versus the test compound concentrations and for non-linear regression analysis of the data. Depending on the range of data points defining the inhibition curve, the data may have been fit to the 4-parameter logistic equation.

EXAMPLE 74

The table below provides data for compounds of Formula (I) obtained using the assays described in Example 73, above.

Cmpd	IC ₅₀ (nM)				
	CYP3A4	CYP1A2	CYP2C9	CYP2C19	CYP2D6
1	20	>10000	7371	6222	>10000
2	18	>10000	>10000	>10000	>10000
3	37	>10000	>10000	>10000	8708
4	58	>10000	3266	2675	>10000
5	15	5566	3246	3738	7330
6	27	>10000	5672	7921	4965
7	21	>10000	8168	>10000	8485
8	22	9177	2526	3254	2487

Cmpd	IC ₅₀ (nM)				
	CYP3A4	CYP1A2	CYP2C9	CYP2C19	CYP2D6
9	21	>10000	2515	2270	2524
10	17	>10000	2326	7020	2105
11	21	5066	2876	3307	5989
12	50	1474	5321	3982	6362
13	10	>10000	4668	6397	>10000
14	17	5522	2205	2602	3704
15	16	2423	1387	1246	2076
16	18	>10000	7473	4269	1929
17	29	>10000	>10000	>10000	4041
18	29	>10000	>10000	4792	>10000
19	50	>10000	1655	2419	9974
20	35	>10000	>10000	9911	>10000
21	35	>10000	4077	8705	7524
22	26	>10000	1759	4689	3213
23	7	>10000	4373	3160	2924
24	11	>10000	3432	2263	3084
25	28	>10000	9590	>10000	2911
26	21	>10000	>10000	>10000	1044
27	9	>10000	>10000	>10000	1761
28	10	>10000	3867	3568	1107
29	20	>10000	2486	4973	2771
30	7	>10000	5551	8402	1624
31	7	>10000	2318	3740	2874
32	24	>10000	>10000	>10000	>10000
33	35	>10000	6520	10000	2091
34	8	>10000	10000	10000	2521
35	4	>10000	>10000	>10000	>10000
36	45	>10000	6984	4255	1721
37	8	>10000	4359	5385	1413
38	31	>10000	6468	4721	3688

Cmpd	IC ₅₀ (nM)				
	CYP3A4	CYP1A2	CYP2C9	CYP2C19	CYP2D6
39	23	>10000	>10000	>10000	1577
40	27	>10000	>10000	>10000	5265
41	30	>10000	2700	2230	2385
42	22	>10000	>10000	2397	1656
43	50	>10000	>10000	4012	2947
44	29	>10000	5090	5842	>10000
45a	12	>10000	7769	5499	>10000
45b	20	>10000	3999	5181	>10000
46	46	>10000	>10000	>10000	>10000
47	20	>10000	9267	7829	>10000
48	31	>10000	1470	2001	4891
49	14	>10000	1807	2114	>10000
50a	16	>10000	4361	4331	4001
50b	5	>10000	1283	4403	>10000
51	22	>10000	>10000	>10000	>10000
52a	7	>10000	>10000	8488	>10000
52b	27	>10000	6200	3672	>10000
53	13	>10000	6117	>10000	9836
54	14	>10000	2864	3346	>10000
55	10	>10000	2968	2389	8032
56	35	>10000	>10000	>10000	7165
57	5	>10000	2808	2643	2448
58	7	>10000	2572	>10000	>10000
59	9	>10000	6484	3362	2209
60	23	>10000	>10000	>10000	4497
61	23	>10000	>10000	1625	2518
62	43	6944	6208	1144	5642
63	46	10000	>10000	>10000	>10000
64	43	3592	2864	4523	3105
65	10	>10000	8776	1344	3359

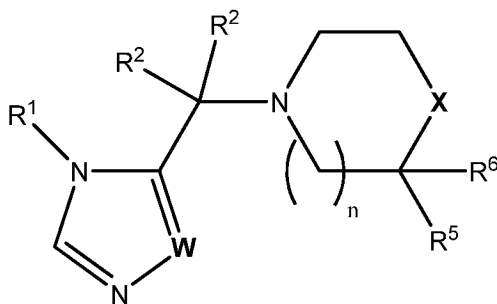
Cmpd	IC ₅₀ (nM)				
	CYP3A4	CYP1A2	CYP2C9	CYP2C19	CYP2D6
66	43	>10000	>10000	>10000	>10000
67	75	>10000	>10000	>10000	>10000
68	80	>10000	>10000	>10000	>10000
69	56	>10000	>10000	>10000	>10000
70	15	>10000	>10000	5952	7680
71	37	>10000	>10000	>10000	>10000
72	14	>10000	>10000	>10000	1173

The present invention is not to be limited by the specific embodiments disclosed in the examples that are intended as illustrations of a few aspects of the invention and any embodiments that are functionally equivalent are within the scope of this invention. Indeed, various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art and are intended to fall within the scope of the appended claims.

A number of references have been cited herein, the entire disclosures of which are incorporated herein by reference.

CLAIMS

- 5 1. A compound having the formula (I):



(I)

- 10 or a pharmaceutically acceptable salt thereof,
wherein:

n is 0 or 1;

W is -N= or -CH= ;

X is $\text{-C(R}^3\text{)(R}^4\text{)-}$, $\text{-N(R}^3\text{)-}$ or $\text{-S(O)}_2\text{-}$;

- 15 R^1 is selected from $\text{-(C}_1\text{-C}_6\text{ alkylene)-aryl}$, $\text{-(C}_1\text{-C}_6\text{ alkylene)-(5 or 6-membered heteroaryl)}$, $\text{-(C}_1\text{-C}_6\text{ alkylene)-O-aryl}$, $\text{-(C}_1\text{-C}_6\text{ alkylene)-O-(5 or 6-membered heteroaryl)}$ and $\text{C}_3\text{-C}_6\text{ cycloalkyl}$, wherein any aryl, heteroaryl or $\text{C}_3\text{-C}_6\text{ cycloalkyl}$ group can be optionally substituted with up to four R^9 groups, which can be the same or different, and wherein said $\text{C}_3\text{-C}_6\text{ cycloalkyl}$ group can be fused to a benzene ring and said fused benzene ring can be optionally
20 substituted with up to four R^9 groups, which can be the same or different;

each occurrence of R^2 is independently selected from H, $\text{C}_1\text{-C}_6\text{ alkyl}$, -OH , $\text{-O-(C}_1\text{-C}_6\text{ alkyl)}$ and $\text{-(C}_1\text{-C}_6\text{ alkylene)-O-(C}_1\text{-C}_6\text{ alkyl)}$; or the two R^2 groups can be joined together with the atom to which they are attached to form a $\text{C}_3\text{-C}_6\text{ cycloalkyl}$ ring;

- R^3 and R^4 are independently selected from H, halo, -OH , -CN , Y, -O-Y , -C(O)-Y ,
25 -C(O)-O-Y , $\text{-(C}_1\text{-C}_6\text{ alkylene)-Y}$, $\text{-(C}_1\text{-C}_6\text{ alkylene)-C(O)-Y}$, $\text{-(C}_1\text{-C}_6\text{ alkylene)-C(O)-O-Y}$ and $\text{-(C}_1\text{-C}_6\text{ alkylene)-O-Y}$, wherein each Y is independently selected from:

- (1) $\text{C}_1\text{-C}_6\text{ alkyl}$,
- (2) $\text{C}_1\text{-C}_6\text{ haloalkyl}$,
- (3) $\text{C}_1\text{-C}_6\text{ hydroxyalkyl}$,

- (4) C₃-C₆ cyclohaloalkyl,
- (5) C₃-C₆ cycloalkyl,
- (6) phenyl, wherein said phenyl group can be optionally substituted with up to four R⁷ groups,
- 5 (7) 5 or 6-membered heteroaryl, wherein said 5 or 6-membered heteroaryl group can be optionally substituted with up to four R⁷ groups, and
- (8) 5 or 6-membered monocyclic heterocycloalkyl or 9 or 10-membered bicyclic heterocycloalkyl, wherein said 5 or 6-membered monocyclic heterocycloalkyl group can optionally form a spirocycle with a C₃-C₆ cycloalkyl group or another 5
- 10 or 6-membered monocyclic heterocycloalkyl group, and wherein said 5 or 6-membered monocyclic heterocycloalkyl group and said 9 or 10-membered bicyclic heterocycloalkyl group can be optionally substituted on one or more ring carbon atoms with up to four R⁷ groups, which can be the same or different, and wherein a ring carbon atom of a 5 or 6-membered monocyclic heterocycloalkyl group may be
- 15 functionalized as a carbonyl group;

or R³ and R⁴ together with the carbon atom to which they are attached are joined together to form a 5 or 6-membered monocyclic heterocycloalkyl group, wherein said heterocycloalkyl group can be optionally substituted on one or more ring carbon atoms with up to four R⁷ groups,

20 which can be the same or different, and wherein a ring carbon atom of a 5 or 6-membered monocyclic heterocycloalkyl group may be functionalized as a carbonyl group;

R⁵ is selected from H, C₁-C₆ alkyl, phenyl, -C(O)N(R⁸)₂ and -C(O)-Z, wherein Z is selected from piperidinyl, piperazinyl and morpholinyl and wherein said Z is optionally

25 substituted with 1 to 3 halo groups, and phenyl is optionally substituted with -N(R⁸)₂,

R⁶ is H or may be joined together with R⁵ to form carbonyl,

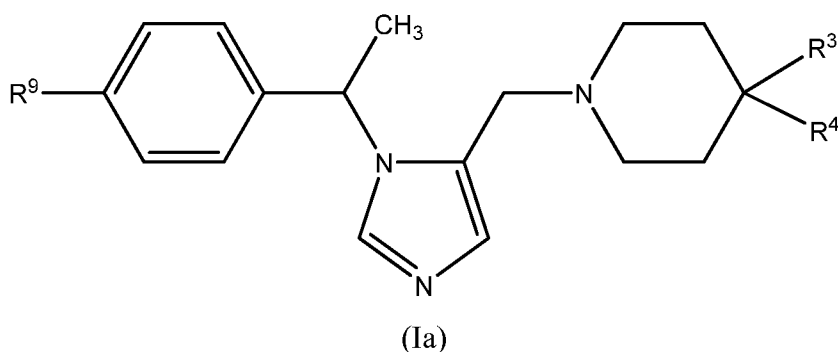
each occurrence of R⁷ and each occurrence of R⁹ are independently selected from C₁-C₆

30 alkyl, phenyl, benzyl, 5 or 6-membered heteroaryl, -CH₂-(5 or 6-membered heteroaryl), 5 or 6-membered heterocycloalkyl, -CH₂-(5 or 6-membered heterocycloalkyl), C₁-C₆ hydroxyalkyl, C₁-C₆ haloalkyl, halo, -CN, -N(R⁸)₂, -(C₁-C₆ alkylene)-N(R⁸)₂, -OR⁸, -C(O)OR⁸, -SR⁸, -S(O)₂R⁸, -C(O)N(R⁸)₂, -(C₁-C₆ alkylene)-C(O)OR⁸, -(C₁-C₆ alkylene)-SR⁸, -(C₁-C₆ alkylene)-S(O)₂R⁸ and -(C₁-C₆ alkylene)-C(O)N(R⁸)₂, wherein said phenyl, 5 or 6-membered heteroaryl and 5 or 6-

membered heterocycloalkyl groups can be optionally substituted with one to three groups selected from C₁-C₆ alkyl, halo, C₁-C₆ hydroxyalkyl, C₁-C₆ haloalkyl, halo, -CN, -N(R⁸)₂ and -OR⁸; and

each occurrence of R⁸ is independently H, C₁-C₆ alkyl or benzyl optionally substituted with one or two methoxy groups.

2. The compound of claim 1, having the formula (Ia):



or a pharmaceutically acceptable salt thereof.

3. The compound of claim 2, or a pharmaceutically acceptable salt thereof, wherein R⁹ is -F or -CN.

4. The compound of claim 3, or a pharmaceutically acceptable salt thereof, wherein

R³ is selected from (1) C₁-C₆ alkyl, (2) C₃-C₆ cycloalkyl, (3) phenyl, wherein said phenyl group can be optionally substituted with up to four halo groups, (4) 5 or 6-membered heteroaryl, wherein said 5 or 6-membered heteroaryl group can be optionally substituted with methyl, and (5) 5 or 6-membered monocyclic heterocycloalkyl; and

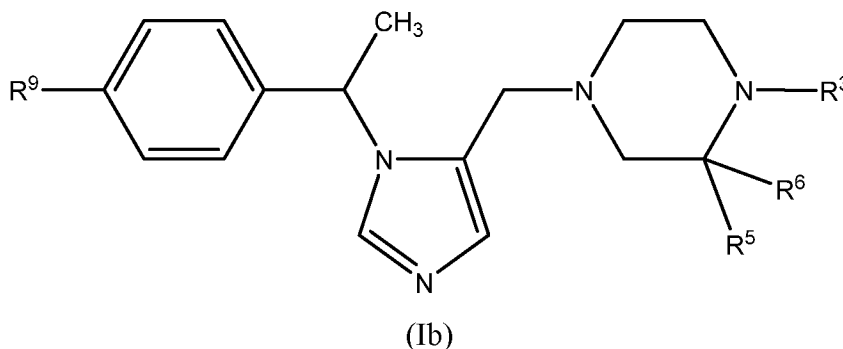
R⁴ is selected from -CN or -CH₃.

5. The compound of claim 3, or a pharmaceutically acceptable salt thereof, wherein

R^3 is selected from benzo[d]oxazol-2-yl and benzo[d]thiazol-2-yl, said benzo[d]oxazol-2-yl and benzo[d]thiazol-2-yl groups each optionally substituted with 1 to 3 groups independently selected from: halo, $-\text{CH}_3$ and $-\text{OCH}_3$; and

5 R^4 is H.

6. The compound of claim 1, having the formula (Ib):



or a pharmaceutically acceptable salt thereof,

7. The compound of claim 6, or a pharmaceutically acceptable salt thereof, wherein
15 R^9 is $-\text{F}$ or $-\text{CN}$.

8. The compound according to Claim 7, or a pharmaceutically acceptable salt thereof, wherein R^3 is thiazolyl substituted with $-(\text{C}_1\text{-C}_6 \text{ alkylene})-\text{S}(\text{O})_2\text{R}^8$, R^5 is H and R^6 is H.

20 9. The compound according to Claim 7, or a pharmaceutically acceptable salt thereof, wherein R^3 is phenyl, R^5 is $-\text{C}(\text{O})-\text{Z}$, wherein Z is selected from piperidinyl, piperazinyl and morpholinyl and wherein said Z is optionally substituted with 1 to 3 halo groups, and R^6 is H.

25 10. The compound according to Claim 7, or a pharmaceutically acceptable salt thereof, wherein R^3 is $-\text{C}(\text{O})-\text{Y}$, Y is selected from (1) $\text{C}_1\text{-C}_6$ alkyl, (2) 1-methylcyclopropyl, (3) cyclobutyl optionally substituted with one or two halo groups, (4) phenyl, (5) pyridinyl, and (6) tetrahydro-2H-pyran-4-yl, R^5 is selected from H, $\text{C}_1\text{-C}_4$ alkyl and phenyl, and R^6 is H.

11. The compound according to Claim 7, or a pharmaceutically acceptable salt thereof, wherein

R^3 is $-\text{CH}_2\text{-Y}$,

Y is selected from phenyl, imidazo[1,2-a]pyridinyl, oxadiazolyl and thiazolyl, wherein
 5 said Y is optionally substituted with a group selected from: (1) phenyl wherein said phenyl is optionally substituted with one or two methoxy groups, (2) $-\text{N}(\text{R}^8)_2$, (3) morpholinyl, (4) piperazinyl wherein said piperazinyl is optionally substituted with a methyl group, and (5) triazolylmethyl; and

10 R^5 and R^6 are joined together to form carbonyl.

12. The compound according to Claim 7, or a pharmaceutically acceptable salt thereof, wherein

R^3 is selected from $\text{C}_1\text{-C}_6$ hydroxyalkyl, $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-C(O)-Y}$, $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-C(O)-O-Y}$ and $-(\text{C}_1\text{-C}_6 \text{ alkylene})\text{-O-Y}$, where Y is $\text{C}_1\text{-C}_6$ alkyl;
 15 and

R^5 is H and R^6 is H.

20 13. A compound selected from the following:

(R)-4-Ethyl-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperidine-4-carbonitrile;

(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-isopropylpiperidine-4-carbonitrile;

25 (R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidine-4-carbonitrile;

1-((1-(benzo[d]thiazol-2-ylmethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidine-4-carbonitrile;

(R)-4-cyclopentyl-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperidine-4-carbonitrile;

(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-propylpiperidine-4-carbonitrile;

30 (R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-(tetrahydro-2H-pyran-4-yl)piperidine-4-carbonitrile;

(R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-isobutylpiperidine-4-carbonitrile;

- (R)-3-ethyl-5-(1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidin-4-yl)-1,2,4-oxadiazole;
- (R)-5-(1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidin-4-yl)-3-methyl-1,2,4-oxadiazole;
- 5 (R)-5-(1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-methylpiperidin-4-yl)-3-isopropyl-1,2,4-oxadiazole;
- 1-((1-(1-(4-cyanophenyl)cyclopropyl)-1H-imidazol-5-yl)methyl)-4-(4-fluorophenyl)piperidine-4-carbonitrile;
- (R)-1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-phenylpiperidine-4-carbonitrile
- 10 (R)-methyl 1-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-4-phenylpiperidine-4-carboxylate;
- 5-((3,3-difluoropyrrolidin-1-yl)methyl)-1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazole;
- 1-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)pyrrolidin-3-ol;
- 4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)-1,4-diazepan-2-one;
- 15 (R)-4-(1-(5-((4-oxo-1-phenyl-1,3,8-triazaspiro[4.5]decan-8-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
- 4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)thiomorpholine 1,1-dioxide;
- (R)-4-(1-(5-((4-(benzo[d]oxazol-2-yl)piperidin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
- 20 (R)-4-(1-(5-((4-(benzo[d]thiazol-2-yl)piperidin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
- (R)-2-(4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
- (R)-4-(1-(5-((4-(benzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
- 25 4-(1-(5-((4-(benzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)cyclopropyl)benzonitrile;
- 2-(4-((1-(2-isopropoxyethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
- 2-(4-((1-(3-methylbutan-2-yl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
- (R)-4-(1-(5-((4-(7-fluorobenzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
- 30 (R)-4-(1-(5-((4-(7-methylbenzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
- (R)-4-(1-(5-((4-(6-fluorobenzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;

- (R)-4-(1-(5-((4-(6,7-difluorobenzo[d]oxazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
2-(4-((1-(1-(tetrahydro-2H-pyran-4-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
5 2-(4-((1-(2-(pyridin-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
2-(4-((1-(1-(4-(methylsulfonyl)phenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
6,7-difluoro-2-(4-((1-(1-(tetrahydro-2H-pyran-4-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
10 2-(4-((1-(3,3,3-trifluoro-2-methylpropyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
2-(4-((1-(4-fluorophenethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)benzo[d]oxazole;
(R)-4-(1-(5-((4-(6-methoxybenzo[d]thiazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
15 (R)-4-(1-(5-((4-(1H-benzo[d]imidazol-2-yl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
(R)-5-(ethylsulfonyl)-2-(4-((1-(1-(4-fluorophenyl)propan-2-yl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)thiazole;
(R)-5-(2-(ethylsulfonyl)ethyl)-2-(4-((1-(1-(4-fluorophenyl)propan-2-yl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)thiazole;
20 (R)-2-(4-((1-(1-(4-chlorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)-5-(2-(ethylsulfonyl)ethyl)thiazole;
(R)-2-(4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)-5-(2-(ethylsulfonyl)ethyl)thiazole;
25 N-(tert-butyl)-4-((1-((R)-1-(4-cyanophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-phenylpiperazine-2-carboxamide;
4-((1R)-1-(5-((4-phenyl-3-(piperidine-1-carbonyl)piperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
4-((1R)-1-(5-((3-(morpholine-4-carbonyl)-4-phenylpiperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
30 4-((1R)-1-(5-((3-(4,4-difluoropiperidine-1-carbonyl)-4-phenylpiperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
((S)-4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-phenylpiperazin-2-yl)(piperidin-1-yl)methanone;

- (4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(5-methylisoxazol-3-yl)methanone;
- (4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(phenyl)methanone;
- 5 (4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(phenyl)methanone;
- 1-(4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)ethanone;
- (4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(tetrahydro-2H-pyran-4-yl)methanone;
- 10 (4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(tetrahydro-2H-pyran-4-yl)methanone;
- (4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2-phenylpiperazin-1-yl)(pyridin-2-yl)methanone;
- 15 (4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-2,6-dimethylpiperazin-1-yl)(1-methylcyclopropyl)methanone;
- (2-(tert-butyl)-4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)(phenyl)methanone;
- (2,6-dimethyl-4-((1-(1-(tetrahydro-2H-pyran-4-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)(1-methylcyclopropyl)methanone;
- 20 (2-(4-(dimethylamino)phenyl)-4-((1-((R)-1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)(1-methylcyclopropyl)methanone;
- 4-((1R)-1-(5-((4-(3,3-difluorocyclobutanecarbonyl)-3,5-dimethylpiperazin-1-yl)methyl)-1H-imidazol-1-yl)ethyl)benzonitrile;
- 25 (4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)(phenyl)methanone;
- 1-(4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)ethanone;
- (R)-1-benzyl-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one;
- 30 (R)-1-(2-((1H-1,2,4-triazol-1-yl)methyl)benzyl)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one;
- (R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-(imidazo[1,2-a]pyridin-2-yl)methyl)piperazin-2-one;

(R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((5-(4-methoxyphenyl)-1,2,4-oxadiazol-3-yl)methyl)piperazin-2-one;

(R)-1-((2-((2,4-dimethoxybenzyl)amino)thiazol-5-yl)methyl)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one;

5 (R)-1-((2-(dimethylamino)thiazol-5-yl)methyl)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-2-one;

(R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((2-(methylamino)thiazol-5-yl)methyl)piperazin-2-one;

10 (R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((2-morpholiniothiazol-5-yl)methyl)piperazin-2-one;

(R)-4-((1-(1-(4-fluorophenyl)ethyl)-1H-imidazol-5-yl)methyl)-1-((2-(4-methylpiperazin-1-yl)thiazol-5-yl)methyl)piperazin-2-one;

ethyl 2-(4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)acetate;

15 2-(4-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)piperazin-1-yl)ethanol; and

1-((1-(1-(4'-fluoro-[1,1'-biphenyl]-2-yl)ethyl)-1H-imidazol-5-yl)methyl)-4-(2-methoxyethyl)piperazine;

20 or a pharmaceutically acceptable salt of any of the foregoing compounds.

14. A pharmaceutical composition comprising an effective amount of a compound of claims 1 to 13 and a pharmaceutically acceptable carrier.

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15. The pharmaceutical composition of claim 10, further comprising an anti-HIV drug.

16. The pharmaceutical composition of claim 15, wherein said anti-HIV drug is selected from an HIV protease inhibitor, an HIV integrase inhibitor, a nucleoside reverse transcriptase inhibitor and a non-nucleoside reverse-transcriptase inhibitor.

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17. The pharmaceutical composition of claim 16, wherein said anti-HIV drug is selected from raltegravir, lamivudine, abacavir, darunavir, ritonavir, dolutegravir, atazanavir, elvitegravir and lopinavir.

18. The pharmaceutical composition of claim 17, further comprising a second anti-HIV drug, which is selected from an HIV protease inhibitor, an HIV integrase inhibitor, a nucleoside reverse transcriptase inhibitor and a non-nucleoside reverse-transcriptase inhibitor.

19. A method for inhibiting a CYP3A enzyme in a subject, comprising administering to said subject a compound of claims 1 to 13, or pharmaceutically acceptable salt thereof, in an amount that is effective to inhibit a CYP3A enzyme in said subject.

20. A method for improving the pharmacokinetics of a therapeutic compound that is metabolized by a CYP3A enzyme in subject, said method comprising administering to said subject in need of such treatment a combination of: (a) said therapeutic compound that is metabolized by a CYP3A enzyme and (b) a compound of claim 1, or a pharmaceutically acceptable salt thereof.

21. The method of claim 20, wherein said therapeutic compound is an anti-HIV drug.

22. The method of claim 21, wherein said anti-HIV drug is selected from an HIV protease inhibitor, an HIV integrase inhibitor, a nucleoside reverse transcriptase inhibitor and a non-nucleoside reverse-transcriptase inhibitor.

23. The method of claim 22, wherein said anti-HIV drug is selected from raltegravir, lamivudine, abacavir, ritonavir, dolutegravir, atazanavir, darunavir, elvitegravir and lopinavir.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/086923

A. CLASSIFICATION OF SUBJECT MATTER

C07D 249/08(2006.01)i; C07D 403/02(2006.01)i; C07D 401/14(2006.01)i; A61K 31/415(2006.01)i; A61K 31/4196(2006.01)i; A61P 31/18(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C07D249/-; C07D403/-; C07D401/-; A61K31/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,WPI,EPODOC,CNKI,Wanfang Data, Pubmed, ISI web of Knowledge, STN on the Web: p450, cyp3a4, 3a4, inhibitor, pharmacokinetics, triazole, imidazole, hiv

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/0021011 A1 (PFIZER INC.) 24 January 2008 (2008-01-24) see the abstract, paragraphs [0003]-[0106]	1-23
A	US 2006/0009645 A1 (SMITH VANESSA ET AL.) 12 January 2006 (2006-01-12) see the abstract, claims 1-51	1-23
A	US 2007/0167497 A1 (PFIZER INC.) 19 July 2007 (2007-07-19) see the abstract, claims 1-17	1-23
A	WO 2006/108879 A2 (TIBOTEC PHARM. LTD. ET AL.) 19 October 2006 (2006-10-19) see the abstract, claims 1-19	1-23

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

14 July 2014

Date of mailing of the international search report

12 August 2014

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/086923

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: **19-23**
because they relate to subject matter not required to be searched by this Authority, namely:

[1] Although claims 19-23 direct to a method of treatment of the patients, the search has been carried out and based on the use of the compound or pharmaceutical composition for the manufacturing of a medicament for the treatment of diseases.
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2013/086923

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
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				EP	2046774	A1	15 April 2009
				NZ	574207	A	29 October 2010
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				TW	I334867	B	21 December 2010
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				PH	12009500192	A	10 January 2008
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				EP	1937639	A2	02 July 2008
				NO	20081844	A	29 May 2008
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				MX	PA08002924	A	30 April 2008
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				VN	10009339	B	25 July 2011
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				SG	140676	A1	28 April 2008
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2013/086923

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		US 2008287488 A1	20 November 2008
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